GEORGE F. NORDENHOLT, *Editor*

Thanksgiving 1940

When the Pilgrims inaugurated Thanksgiving Day they came together primarily to thank God through prayer for everything they had and for all they had accomplished. It is significant that they did not beseech the Creator to make things easy for them. Rather, they prayed for continued strength in body and soul to the end that they might be victorious over the trials, hardships and dangers they were facing.

The Pilgrims did not sit down and complain because some one else had not come over ahead of them to clean out the wilderness and tame the savages. Nor did they gather to complain about the progress of their work, or to bicker over how much more could have been done—if. Their only supplication was for more strength and stamina. They expressed thanks for the little they had received in return for their gruelling work in the face of constant danger.

We face Thanksgiving 1940 with conditions entirely different from those which faced the Pilgrims more than three centuries ago. But today's situation also calls for the same stamina, determination, and courage as that required of the Pilgrims. Are we showing the same spirit?

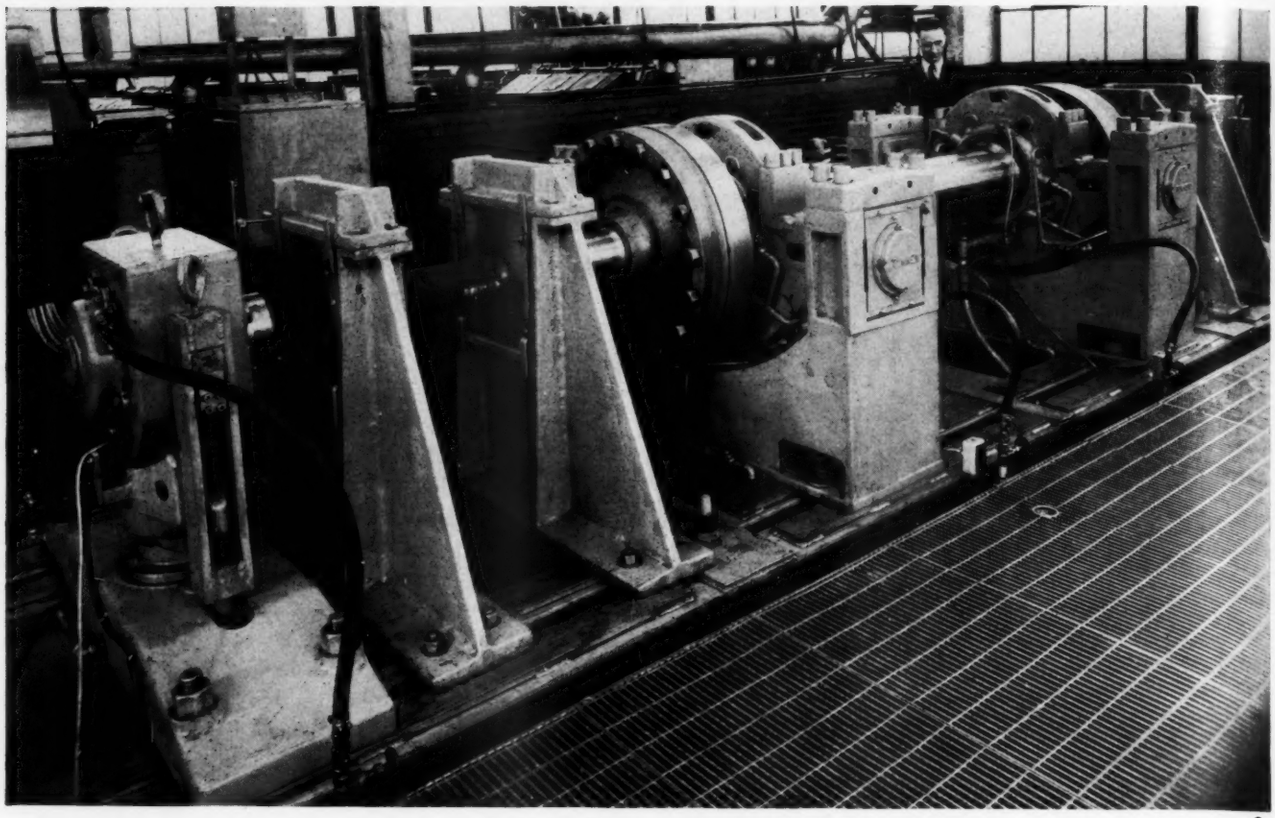
Newspapers and magazines are full of stories that paint gloomy pictures about lack of progress in the defense program. Reams of paper are used to emphasize the "bottleneck" in machine tools and other equipment. Production figures, months old but presented as being current, are cited to show that we are making only 400 Garand rifles a week, that it will take four more years to build a battleship, that we are making only 700 planes a month, that we are short of everything required to arm a force of 2,000,000 men.

Of course we are short of everything required for an army of 2,000,000 men. That is why Knudsen and the National Defense Commission are down in Washington. And it will be April 1942 before we have all the paraphernalia for an army of 2 000,000. But we are making progress at a splendid rate. The tremendous capacity of American industry to increase rapidly its productivity is beginning to be felt. Machine tool production in 1940 will be almost three times that of 1938; Garand rifles are being produced at one arsenal at the rate of more than 500 per day; airplane production will cross 1,000 a month before the year is out, this being more than three times the production rate of a year ago; Navy yards have gone to multiple shifts and destroyers are being launched months ahead of expected schedule; production of raw and semi-finished materials is no longer a pressing problem.

We have much to be thankful for this Thanksgiving. We are still the richest country in the world and have the highest standards of living. We are rapidly on the road to becoming the strongest nation in the world, in the military sense. Our weakness lies in the fact that we are too critical, too unappreciative. Some of us have deteriorated to the state of mind where we expect something for nothing, a reward without working or sacrifices.

Admittedly, the intensive political campaign, which will be over shortly, perhaps even before these lines are read, has engendered much of the criticism. But regardless of who has been or will be elected, the final election returns should signal the return to true Americanism, the rebirth of the spirit that filled the pioneers with grim determination, the spirit of cooperation that brought neighbors together for a house raising bee, the spirit that banded people together to face a common danger, the spirit that found its guidance in the Golden Rule. We must now prove to the atheistic dictators that that way of life is the stronger, more enduring, and inherently victorious. We will do it, but only if we live and think according to the fundamental doctrines of true democracy, as practiced by the hardy pioneers who founded this country. "Glory and love to the men of old—Their sons may copy their virtues bold," are the opening lines of a stirring song.

Thanksgiving 1940! We have much for which to be thankful. Let us give thanks with a full appreciation of the work to be done and the spirit in which it is to be accomplished.



Axle fatigue testing machine with full size axles under test

FATIGUE STRENGTH–I

Of Members as Influenced by Surface Conditions

O. J. HORGER, *Director, Railway Engineering and Research, The Timken Roller Bearing Company*

FATIGUE failure generally originates at a point on the surface of a member because usually with normal stress distribution the stress is greatest at the surface. Furthermore, the stresses concentrate at notches, fillets and similar shaped influences, thus creating highly stressed focal points for the beginning of fatigue fractures. But independent of such shape effects many factors relating to the condition of the surface of the member will have an important bearing on the fatigue strength. Although microscopical irregularities and other surface conditions usually have little influence on strength under static loading they often form the nucleus of fatigue failure.

Not all fatigue fractures start on the surface. Rails often fail from internal fissures which under repeated stressing are propagated to the outer boundaries. Also case carburized, nitrided, or metal sprayed parts sometimes fail in the region of the junction of the surface layer and the parent material. Castings with internal porosity, shrinkage cracks or sand spots sometimes develop fatigue failure which starts below the surface in the region of the defects. Such sub-surface defects, however, constitute a relatively small percentage of fatigue failures.

This article is concerned with the type of fatigue fractures initiating at the surface. Examples supplemented with a correlation of laboratory fatigue tests and service failures will be included to illustrate the effects of many surface condition factors. By this means an approach will be presented for the solution of fatigue problems which regularly confront engineers.

Fatigue tests covering various types of surface finishes ranging from rough turned to superfinishes have brought forth practical data. Specimens of 0.3-in. dia. were tested in a R. R. Moore rotating beam type machine. Specimens ranging from 1½ in. to 7 in. dia. were tested as rotating cantilever beams. All specimens were from one heat of S.A.E. 1045 steel having about 0.47 per cent carbon content. The steel was tested in the hot rolled or as-forged condition without heat-treatment.

Results of tests on 0.3, 1½ and 6 in.

dia. specimens are shown in Fig. 1, where fatigue strength is correlated with the irregularities of surface finish as shown by the profilograph records. A Brush surface analyzer or Abbot profilograph can be used to obtain such records. These and additional instruments for measuring surface finish will be found described in detail in the book, "The Story of Superfinish" by Arthur M. Swigert, Jr., published by Lynn Publishing Company, Detroit, Mich. (PRODUCT ENGINEERING page 384, Aug. 1940)

While various finishes are here compared on the basis of depth of irregularities as measured in micro inches, that is, millionths of inches, it is appreciated that the contour of the surface is also important.

As shown in Fig. 1, the endurance value for the 0.3-in. circumferentially polished specimen is 30,000 lb. per sq. in. but for the same size specimen with a turned surface which is over 30 times as rough as the polished surface, the endurance value is only 28,000 lb. per sq.in. or 7 per cent less. Compared to the 1½ in. specimen with a superfinish, the fatigue strength for a 1½ in. specimen with a turned surface more than 100 times as rough is only about 10 per cent less. Outstanding differences are shown in the 17,500 lb. per sq.in. endurance limit of the 6 in. members as compared with 33,000 lb. per sq.in. for the specimen of 0.3 in. dia. machined from the outer layer of the 6 in. member. Even though the finish was 40 times as rough on the large member as on the small one this fact alone does not explain the low value of 17,500 lb. per sq. in. The tests results from the smaller specimens show that the fatigue strength of this material is not very sensitive to various types of surface finish; furthermore the large member is 20 times larger in dia. than the small one so that, for comparison on the basis of geometric similarity, the surface finish should have been 800 micro inches on the large member. Obviously no definite relationships between size of specimen, roughness and fatigue strength can be formulated from these test results.

The low values of fatigue strength such as obtained with the 6 in. members indicate the danger of arriving at safe operating stresses on the basis of fatigue tests of sample specimens even though these are selected from the large members. The specific reason for this low fatigue strength of large forgings is not definitely known. Recognition has always been given to size effect and the lower physical properties anticipated with large sections when compared with small ones. Processing conditions, however, are much different for the two specimens, which operations naturally introduce additional questionable factors.

Effect of surface finish on shafts of uniform diameter on which wheels were press-fitted are shown in Fig. 2. Fatigue failures occurred in the axle under the wheel fit. Note that the 1¾ in. dia. shafts having a superfinish show 11 per cent greater breaking-off strength than those having a smooth turned finish.

This same material in the heat-treated condition would be expected to show greater divergence in fatigue values of the various surface finishes than are exhibited by the untreated material cited in Fig. 1. Houdremont and Mailänder ("Bending Fatigue Tests of Steel," *Stahl und Eisen*, Number 49, 1929, pages 833-9) have investigated this question for a large number of steels, some results are shown in Fig. 3. In their investigation 0.3 in. dia. specimens with both polished and rough turned surfaces were tested in rotating bending. An 11 thread per in. feed with about 0.004 in. deep thread constituted the rough turned surface. Fig. 3 indicates that as the tensile strength increases the rate of decrease in the fatigue strength of the rough turned surface is larger than that of the polished specimen. Additional test results (H. Bucholtz and E. H. Schulz, "The Question of the Fatigue Strength of the High Value Structural Steel 52," *Mitteilungen aus dem Forschungs Institut*, Vol. 2, Number 6, 1931, pages 97-112) are given in Fig. 4 for materials with specifications as indicated, the types of specimens and surface finishes

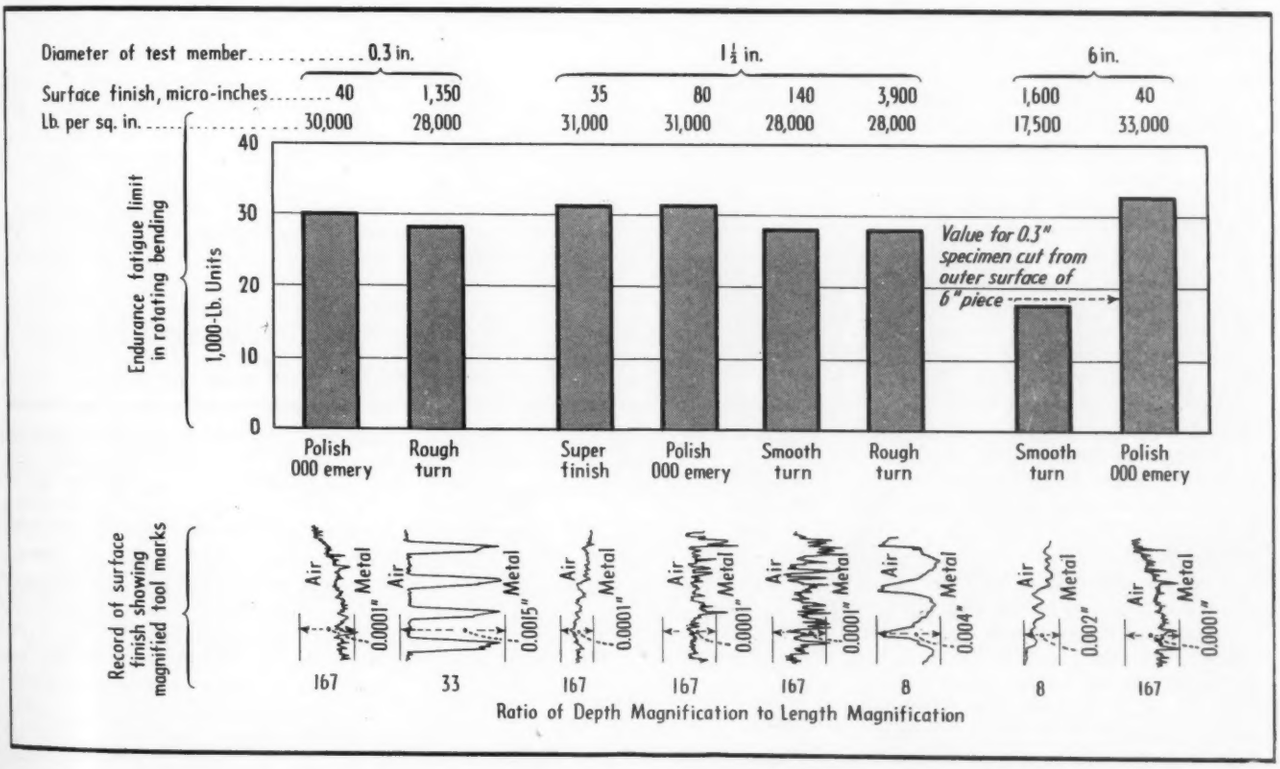


Fig. 1—Endurance fatigue limit in rotating bending for various specimens correlated with different surface finishes

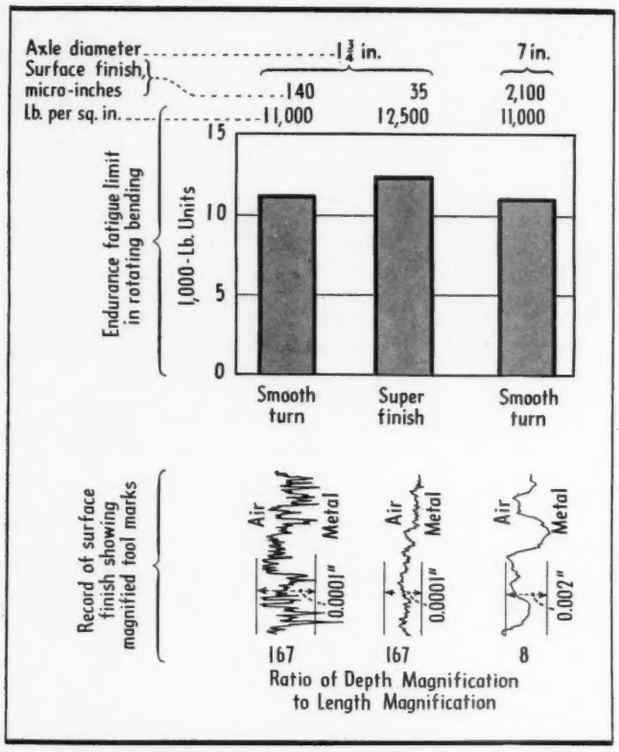


Fig. 2—Breaking-off strength of axles in wheel fit correlated with surface finish profilographs from axles before test

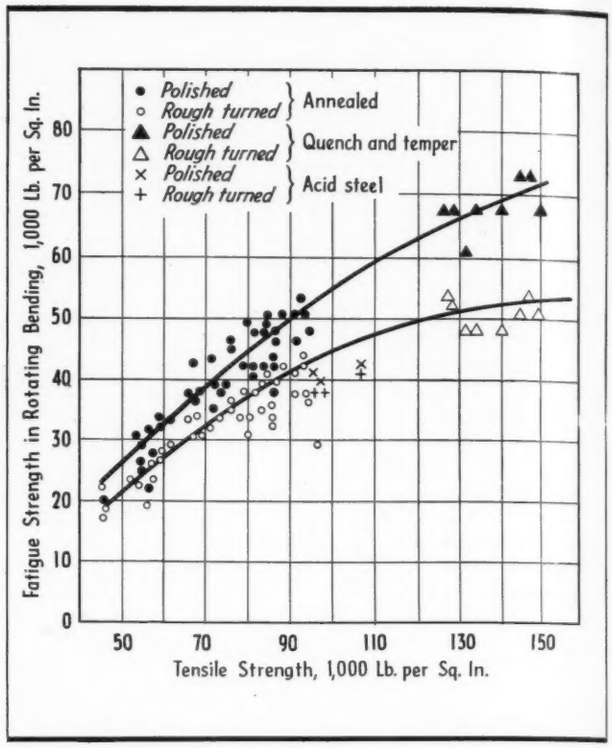


Fig. 3—Relation established by Houdremont and Mailänder between endurance limit and tensile strength for various steels

were the same as those shown in Fig. 3, by Houdremont and Mailänder.

Longitudinal polishing would be expected to give higher fatigue values than those obtained by circumferential polishing which was used to obtain the results presented in Fig. 1. Surface finish marks in planes transverse to the direction of stress have detrimental effects on the fatigue strength. An example of this is shown in Fig. 5 where fatigue failure developed in a 6 in. dia. member in the plane of the tool marks. Service performance of springs and axles are good examples of parts where longitudinal cracks have been found to have little or no influence on the bending fatigue strength. This is true where only bending stresses are present. In the presence of torsional stresses such longitudinal defects have an appreciably detrimental effect.

If plain specimens subjected to reversed bending stresses under atmospheric conditions do not fail within 10 million reversals of stress it is usually considered that they never will fail. Laboratory experience indicates that this is not always true and that failures do sometimes occur between 10 and 50 million reversals. This may be partially explained by the incidental irregularities present in surface finishes which are presumably the same or by variations in certain surface conditions. For instance, polished surfaces are accompanied by residual compressive stresses and the so-called Beilby amorphous layer which differs structurally from the base material. Also, local heating may be produced in dry grinding which will give rise to detrimental residual tensile stresses in the surface. Again in turning, a clean or a torn and smeared surface may result depending upon conditions of cutting velocity, angle, and feed of cut. Roughing cuts may be taken so deep that the metal is damaged to a depth which will not be removed by the smooth turning operations.

Examples of the effect of turning conditions on fatigue strength are given in Table I. These data obtained by E. Siebel and W. Leyensetter ("Influence of Cutting Speed on the Fatigue Strength of Test Specimens," *Zeitschrift des Vereines deutscher Ingenieure*, Vol. 80, Number 22, May 30, 1936) on cold drawn ½ in. bar stock of 0.25 per cent carbon steel indicates that the cutting depth has little effect upon the fatigue strength. However, the amount of feed and cutting velocity are most important, which under suitable conditions can result in as much as 25 per cent increased fatigue strength

Table I—Influence of Cutting Speed on Fatigue Strength

(E. Siebel and W. Leyensetter)

Feed In. per Rev.	Cutting Depth, In.	Cutting Speed, Ft. per Min.	Endurance Limit in Alternate Bending, Lb. per Sq. In.
0.0012	0.040	66 to 74	39,100 to 46,200
0.0012	0.040	387 to 415	46,900 to 49,000
0.007	0.008	82	40,500
0.007	0.008	328	36,900
0.010	0.012	49	39,100
0.010	0.012	394	36,900
Polished condition for comparison			49,700

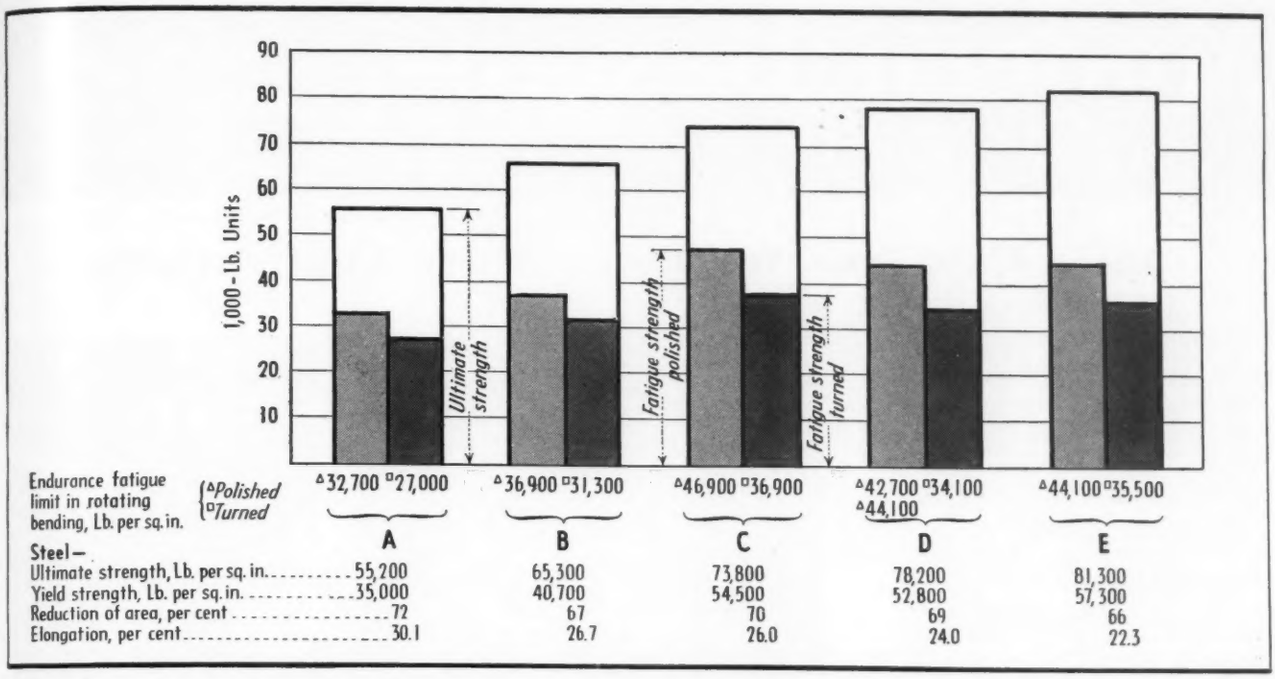


Fig. 4—Relation between fatigue strength and ultimate strength of steel specimens with polished and turned surfaces as established by investigations as conducted by Buchholtz and Schulz

which approaches the value for a polished specimen. The lower cutting speeds introduce greater scatter. To reduce the effect of tool wear cutting was done with a Widia-X tool.

Original investigations of the effect of machine finishes upon fatigue strength of materials were initiated some years ago by W. N. Thomas and H. F. Moore, their results are published with those of others in "Fatigue of Metals," McGraw-Hill Book Company. See "Influence of Chemically and Mechanically Formed Notches on Fatigue of Metals," by D. J. McAdam, Jr. and R. W. Clyne in *Journal of Research*, National Bureau of Standards, Vol. 13, Oct. 1924, for a later review of this subject.

EDITOR'S NOTE: Part II of this article will be presented in the December number. This second installment in the series will describe the work of the author and various investigators dealing with the effects of endurance raising operations on machined surfaces such as burnishing, rolling, fillet rolling, compressing material in critically stressed regions around holes and threads, and press-fitting have on fatigue endurance limits. The influence of surface conditions on fatigue of members under alternate torsional loading, the characteristic differences in stress distribution under torsional loading which lead to odd types of fatigue fractures, and directional properties imposed by rolling mill practice will also be discussed.

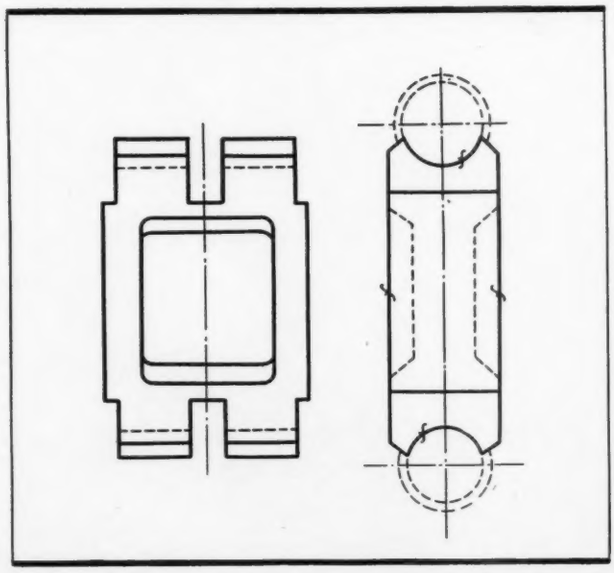
Fig. 5—Fatigue failure of a 6 in. dia. shaft. Failure developed in different planes which correspond with feed of machining tool

Modern Designs

Alloy Cast Iron for Heavy Duty Applications

Toggles and backing plates in cold heading machines of the Ferry Cap & Set Screw Company wore rapidly and did not possess much over-load capacity. To eliminate shutdowns, these parts have been redesigned.

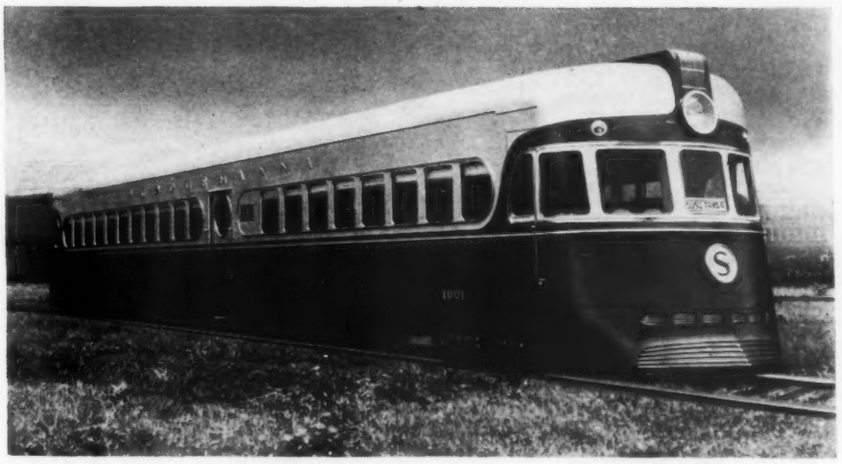
Foundry engineers devised a new method for casting the toggles with a lug of metal at the bearing hole, as shown in line cut, to assure boring a concentric bearing surface in perfect alinement. This hole is then broached, cut to dimension and the bearing surface carefully shaped. Toggles cast in Meehanite have long service life because the knuckle bearing surface of this metal used in connection with a steel shaft provides a finish which cold works and is self-lubricating.

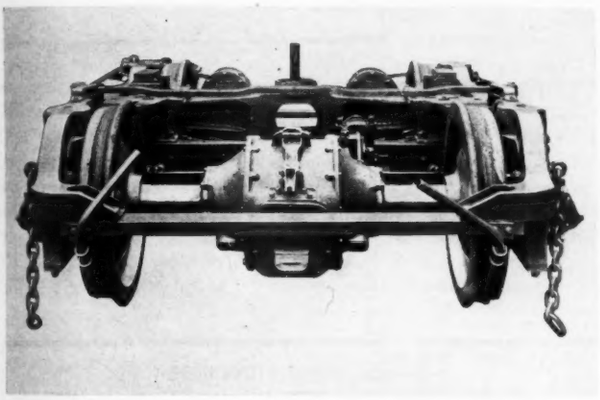


Feed rolls, shown at right, previously were hardened tool steel ring on a cast iron hub. The action of the machine tended to skid the feed roll on the wire and wear a series of flat spots on the ring. Many materials hard enough to withstand wear and crushing had a tendency to scratch the rods. After some experiment, the feed rolls were cast in Meehanite. The Meehanite structure contains finely dispersed graphite particles which act as a lubricating aid. The castings are single units, require no special fabrication.

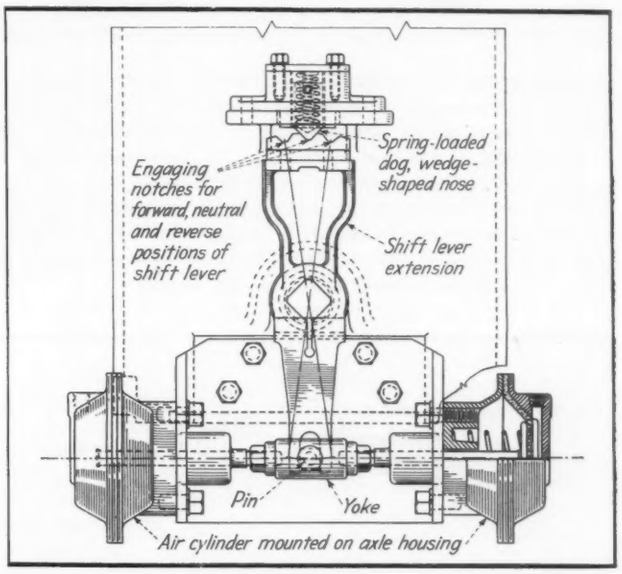
Railcar Driven Through Hydraulic Torque Converter

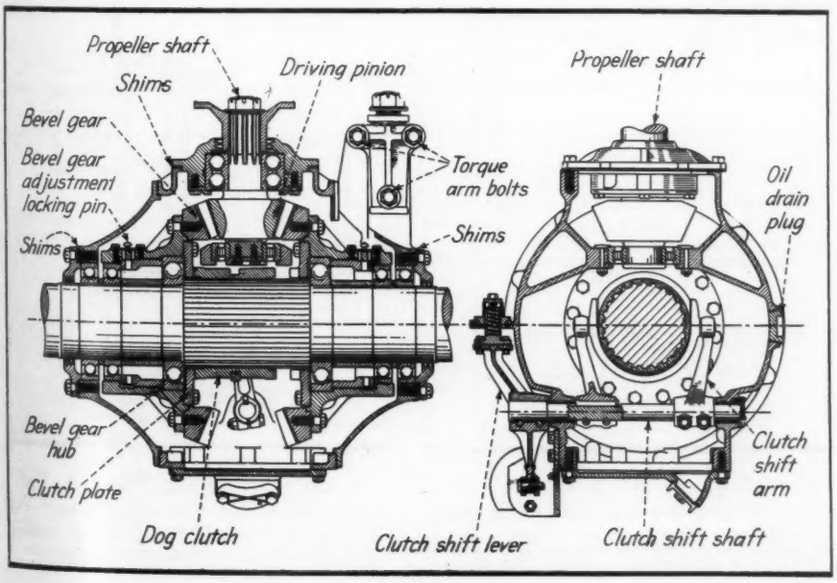
Of lightweight construction, in which high-tensile steels and aluminum alloys predominate, this new streamlined motor-driven railcar was built by the A.C.F. Company for commuter service on the New York, Susquehanna & Western. It is driven by a horizontal Waukesha semi-diesel engine through a Twin-Disc hydraulic torque converter and is equipped with a 6½ ton capacity all-weather air conditioning system, electro-pneumatically controlled.





Power axle design incorporates two floating spiral bevel gears always in mesh with a drive pinion keyed to the propeller shaft from the torque converter. Forward or reverse operation of the car is accomplished by operation of a dog clutch which locks one or the other floating spiral gears to the axle drive shaft. Details of the design are shown below.

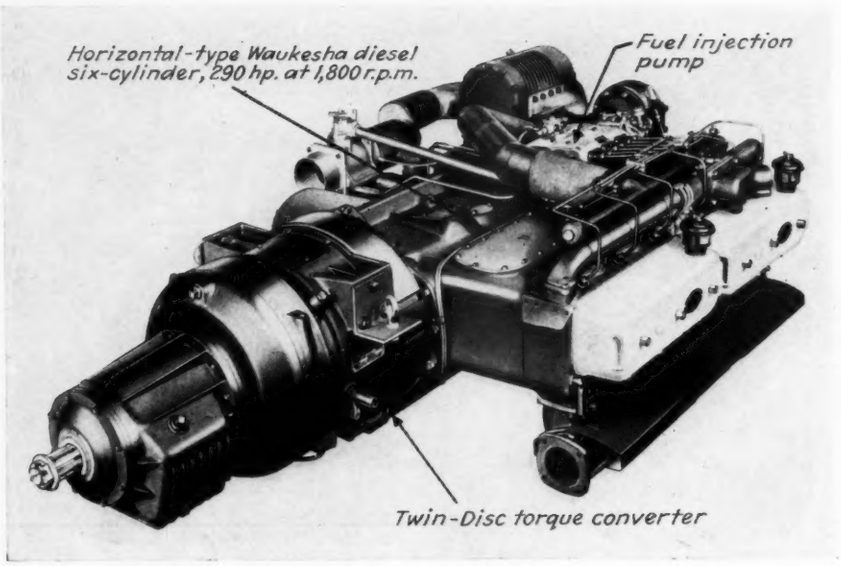

Engaging notches for forward, neutral and reverse positions of shift lever
Spring-loaded dog, wedge-shaped nose
Shift lever extension
Pin
Yoke
Air cylinder mounted on axle housing

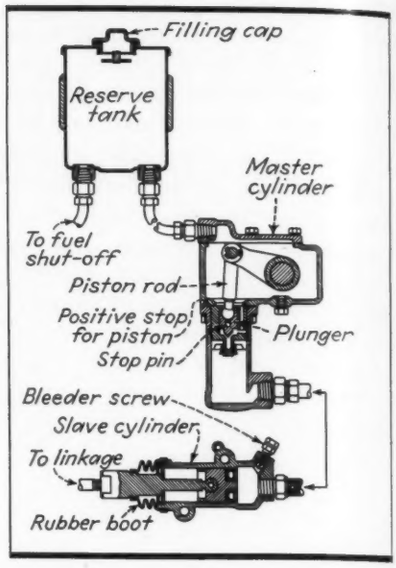


Forward and reverse shift is actuated by air cylinders controlled by a toggle switch on the operator's panel board. Two half-cylinders, mounted on the axle housing, throw the shifting fork. Engaging notches on the shift lever extension provide positive locking of the lever in any one of three positions. As a safety feature, the mechanism is arranged so that the axle clutch cannot be shifted unless an emergency application of the brakes has been made. With pressure in the emergency line, a pneumatically operated relay in the line closes the electrical circuit that controls shifting. Movement of the shift switch then energizes the proper one of two magnetic valves to open the air line to the proper shift cylinder. End play in the completed axle assembly is taken up by shims. Torque arm is cushioned.

(Continued on next page)

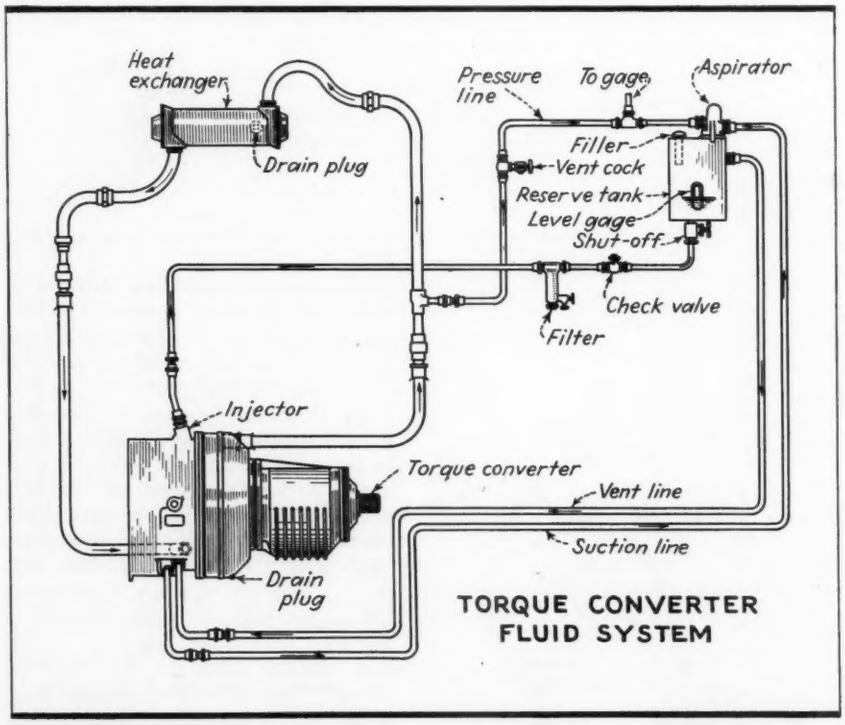
MODERN DESIGNS – Streamlined Motor Railcar *(Continued)*

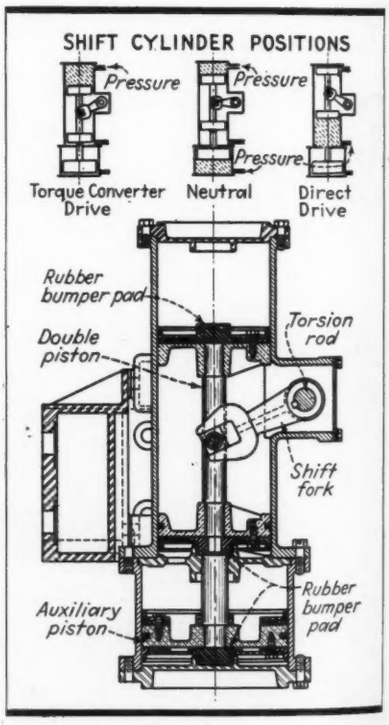




Fuel system operation. When the accelerator pedal is depressed, it puts pressure on fluid in a Bendix master cylinder, which pressure is carried by a tube to a slave cylinder mounted at the engine. Slave cylinder piston actuates a governor accelerator to change spring tension on the governor lever. This lever opens butterfly valve in the suction side of the supercharger line and admits more air, thus decreasing the vacuum in the suction line. A vacuum-operated fuel pump regulator then permits spring pressure in the regulator to increase injector pump stroke, thus feeding more fuel.

To maintain a full system at all times and to allow for expansion and contraction caused by temperature a valve is provided in the master cylinder. When the throttle control pedal is released it spring-lifts a piston rod. As the rod approaches its limit of travel it brings piston against a stop. The rod continues to travel until the plunger bears against a stop pin permitting fluid to flow around the valve needle.

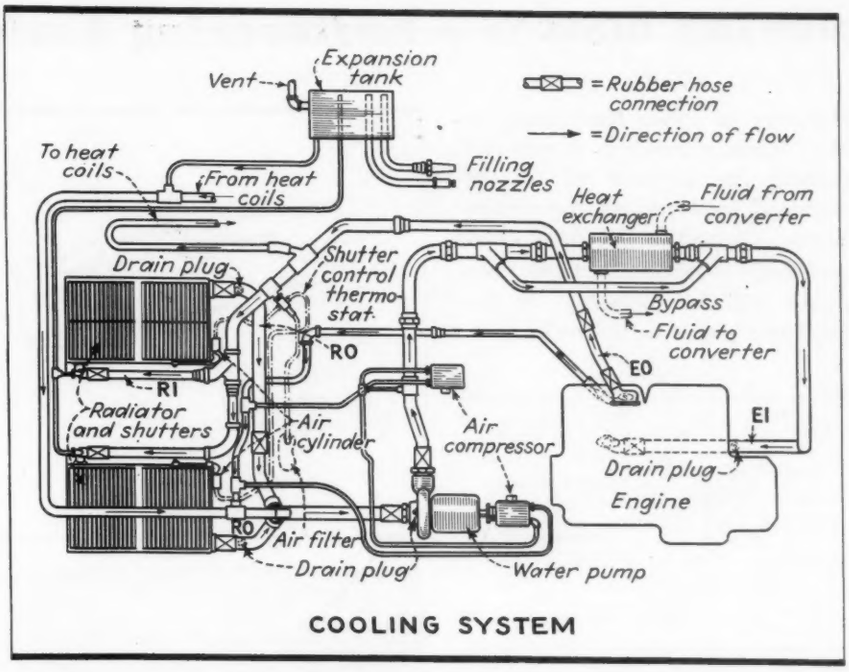




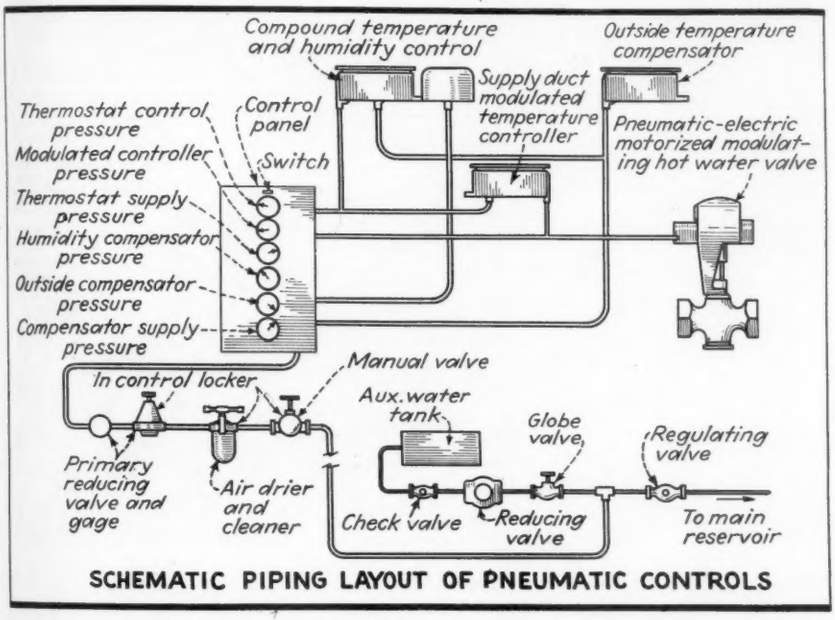
Hydraulic torque converter, described in PRODUCT ENGINEERING, *December, 1939, page 564,* is divided into two elements, one the hydraulic element which provides torque multiplication for acceleration and performance on heavy grades, and the other a direct drive element which couples the engine directly to the drive axle. A Twin-Disc clutch, air-actuated, engages hydraulic or direct drive. Fluid is cooled by water from the engine radiators.

Cooling of engine water is accomplished by two water tube radiators mounted in the shape of an inverted "V" and located between two bulkheads. Two opposed fans are mounted in each bulkhead to draw air through louvres in the car side. Radiator shutters for cold weather operation are operated by thermostatically controlled air cylinders. Movement of $\frac{1}{32}$ in. of the thermostatic element operates the needle valve controlling air admission to these cylinders. An air filter in the air line to the thermostatic valve removes oil or sludge. Water pump, of 225 gal. per min. capacity at 1,800 r.p.m., is V-belt driven from the front end of the engine crankshaft.

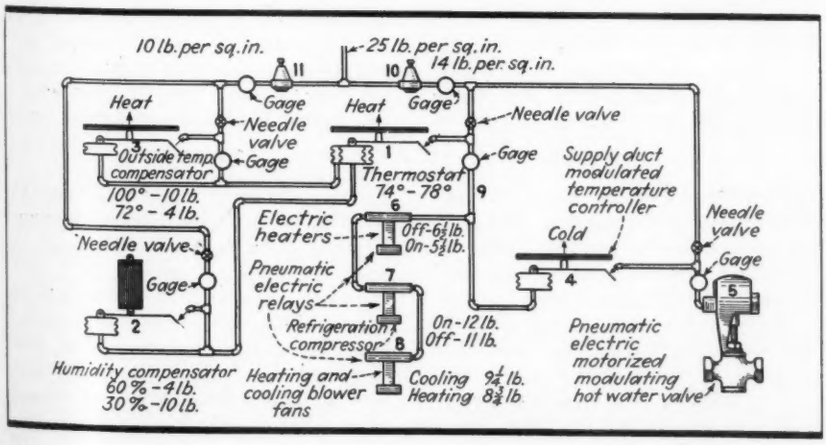
Radiator cooling fans are cast aluminum, and have a steel adapter pinned to the hub. This adapter is splined to the hollow fan shaft which is also V-belt driven. Entire fan assembly is statically and dynamically balanced. Alemite fittings on extensions from shaft bearings provide lubrication.



COOLING SYSTEM



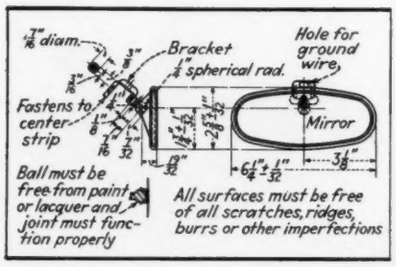
SCHEMATIC PIPING LAYOUT OF PNEUMATIC CONTROLS



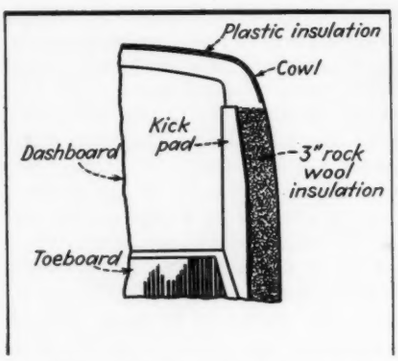
Pneumatic temperature - control system is essentially based upon the supplying of compressed air to a closed piping system at a certain rate and removing it through controlled nozzles at rates which will allow pressure variation from 0 to 14 lb. per sq.in. Movable diaphragms or bellows attached to this closed system operate electric switches which control the electrical parts directly or through relays. The main thermostat *1* is mounted in the exhaust air duct. The pivot end of the flapper lever is attached to a pair of concentric bellows. The position of the inner bellows is determined by the pressure in the humidity compensator *2* control tube. The position of the outer bellows depends on the outside compensator *3* control pipe pressure. The humidity compensator is a part of *1* instrument and exposed to the same air stream. Instrument *3* is mounted in one of the outside air ducts. The humidity compensator *2* and door compensator *3* have a pressure-regulated air supply line giving 10 lb. per sq. in. The outside compensator *3* readjusts in the cooling season the control point of *1* thermostat. The humidity compensator *2* functions in all seasons. At 60 percent and 30 percent relative humidity the respective pressures are 4 and 10 lb. per sq.in. in its control pipe connected to the inner bellows of *1*. Thus, the two compensators separately or together determine the position of the pivot end of the flapper of thermostat *1*. Therefore, *1* instead of holding a fixed temperature has 74 deg. to 78 deg. F. variation of control point depending on conditions at compensators.

MODERN DESIGNS – Engineering Features of 1941 Cars

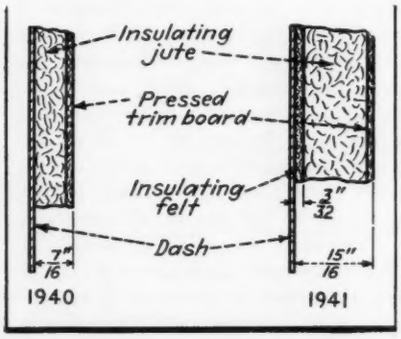
Because of space limitations in the October number, it was not possible to present all of the material collected on the design features found in the 1941 automobiles. Therefore these two pages will be followed by the final two pages in December.

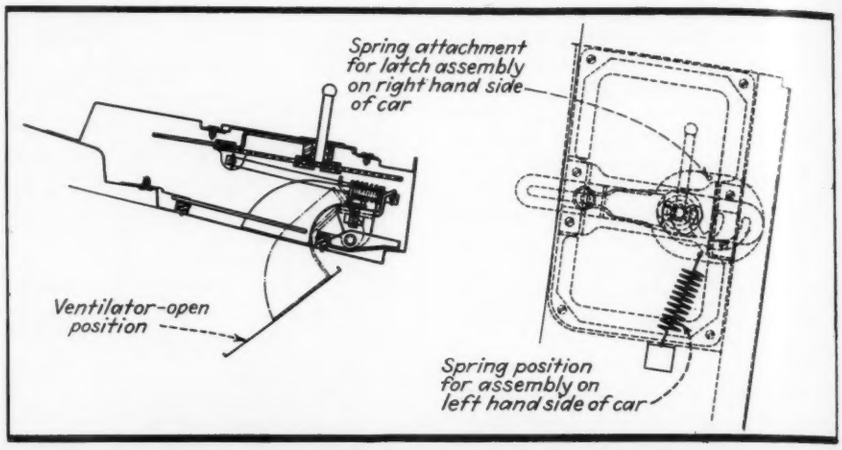


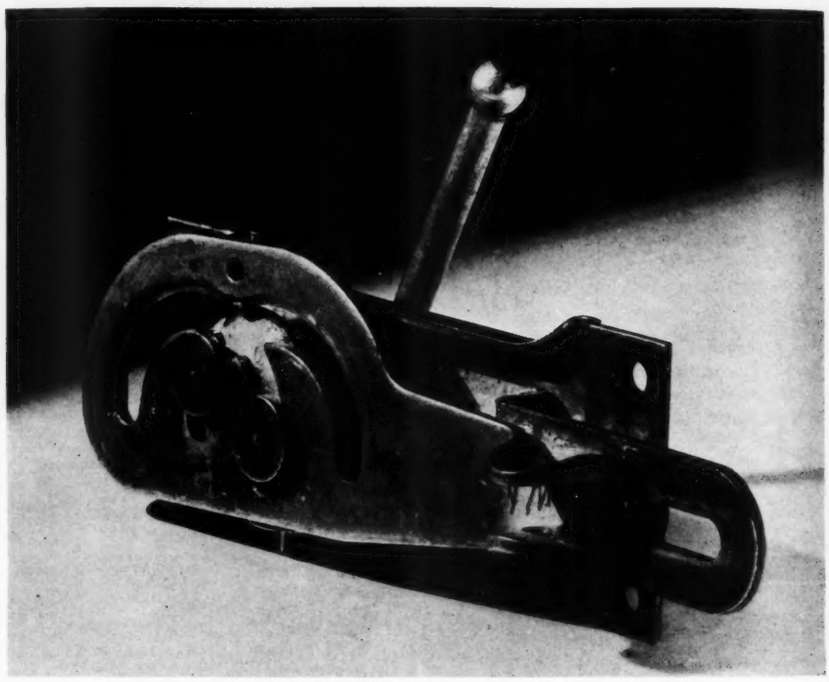
Clearance for interior radio aerial is provided by an offset bracket for mounting ball-and-socket joint of the Studebaker rear-view mirror.



Rock wool insulation is used in the space between the cowl sides and cowl trim panel on either side of the toeboard for the 1941 Pontiac. The solid grid front floor is completely covered with sound-deadening and temperature-resistant padding. Dashboard insulation consists of an increased thickness of jute and insulated felt.



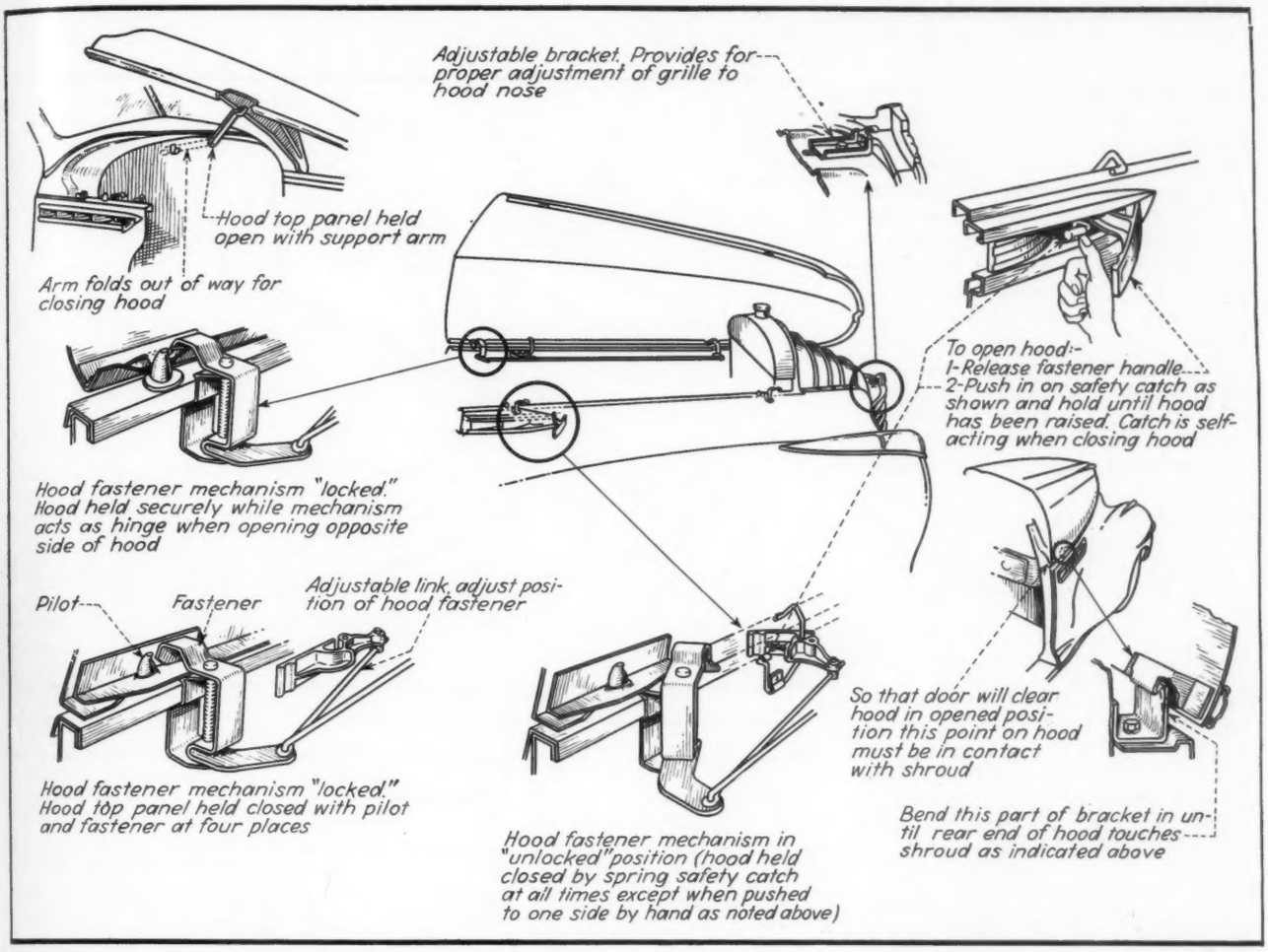

Spring attachment for latch assembly on right hand side of car
Ventilator-open position
Spring position for assembly on left hand side of car



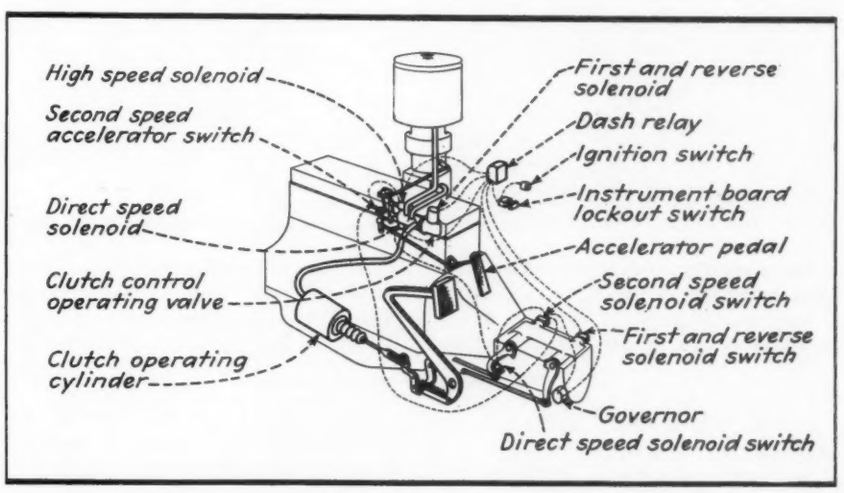
Three position positive latch mechanism for the Studebaker fresh-air intake doors. 180 deg. angular rotation of handle in either direction moves drawbar forward or backward one position. Two equally spaced crankpins mounted on a rotating disk cause drawbar to move through engagement in semicircular grooves. Mechanism is designed for mounting on either side of car. When on the left hand side, spring attachment point is at bottom; for right hand mounting, assembly is turned over and spring attachment point is at top. All pins are same size; drawbar guideway is spot welded to attachment plate.

DIRECT ACTING SHOCK ABSORBERS are mounted inside coil springs in the senior Nash series. Upper controls arms are rubber-insulated. Rear springs are prelubricated and inclosed in metal covers. Fixed ends are mounted in rubber bushings; front ends of springs have been lowered to decrease wind-wander. Motor is cradled in the secondary frame, an integral part of the "Unitized" body.

THREE ADDITIONAL NEEDLE BEARINGS replace the pin and socket bearings formerly used in the Cadillac clutch release lever, to provide smoother operation. Anti-friction washer, placed on the driving side of the clutch release lever, eliminates squeaks. The disk clutch of the Torbend type described in P.E., *Nov. 1939, p. 465*, is continued in the 1941 models.

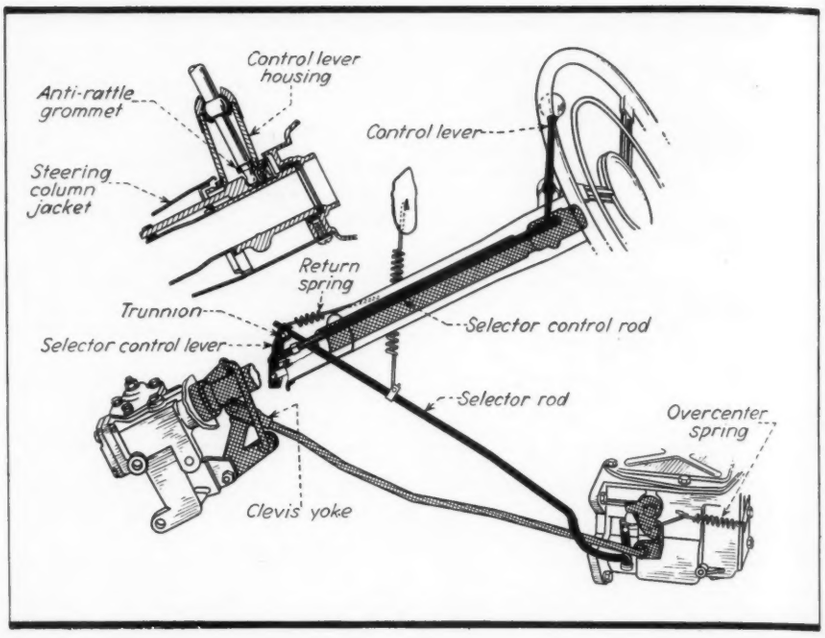

Adjustable bracket. Provides for proper adjustment of grille to hood nose
Hood top panel held open with support arm
Arm folds out of way for closing hood
To open hood:-
1-Release fastener handle
2-Push in on safety catch as shown and hold until hood has been raised. Catch is self-acting when closing hood
Hood fastener mechanism "locked." Hood held securely while mechanism acts as hinge when opening opposite side of hood
Pilot
Fastener
Adjustable link, adjust position of hood fastener
Hood fastener mechanism "locked." Hood top panel held closed with pilot and fastener at four places
So that door will clear hood in opened position this point on hood must be in contact with shroud
Bend this part of bracket in until rear end of hood touches shroud as indicated above
Hood fastener mechanism in "unlocked" position (hood held closed by spring safety catch at all times except when pushed to one side by hand as noted above)

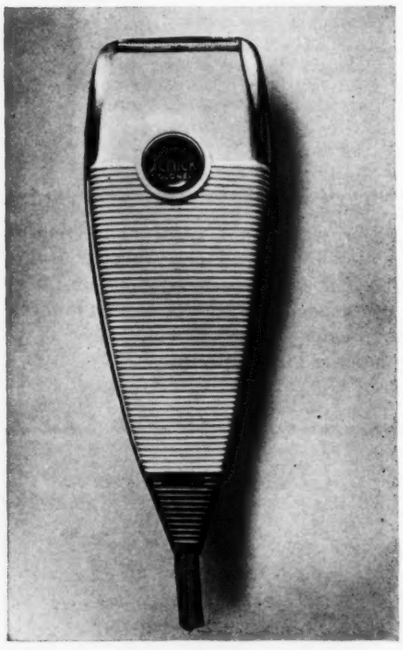
One-piece side opening hood. 1941 Buick has a side hood latch mechanism. To open the hood, one side is unlatched and the entire top raised, opposite latches serving as hinges. The hood may be lifted from either side, or can be removed entirely by unlocking both fasteners. Pivots in fender side assure alignment. A safety arrangement eliminates any possibility of the hood coming off if both fasteners are left in the open position. When the latch is open, a red rubber coated rod end is exposed. This must be pushed toward the center of the car to permit lifting of the hood. When the hood is lowered, the safety catch automatically swings into the locked position.

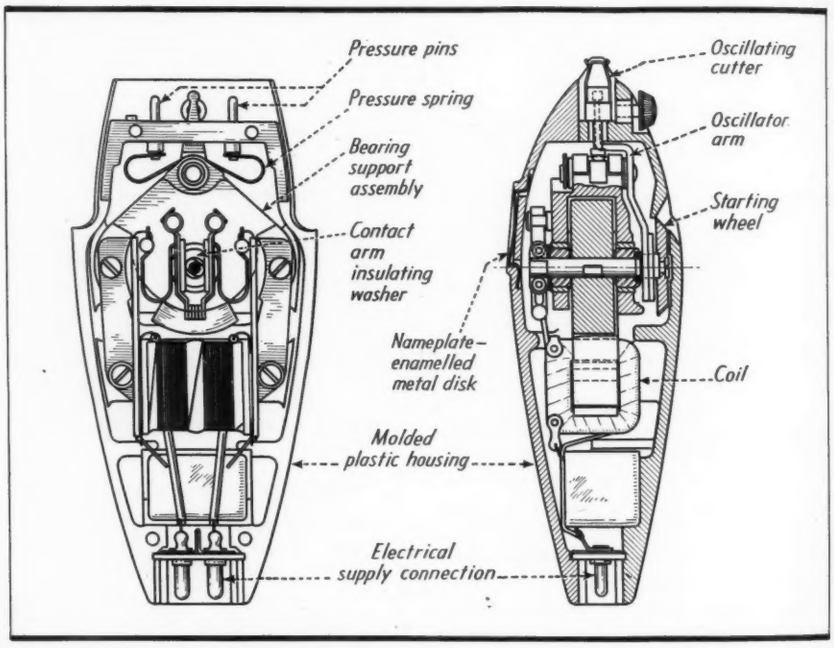


Electromatic clutch for 1941 Packards. With accelerator pedal released, gear shaft lever movement into the first speed position causes the first and reverse switch to energize the solenoid. Movement of solenoid compresses to a predetermined, fixed value a diaphragm spring in the clutch control operating valve. As the accelerator pedal is depressed, the vacuum in the master cylinder is reduced from its maximum to an amount just sufficient to balance the clutch spring load at the initial engaging point. This insures smooth clutch engagement in low, or in reverse gear. After the car is accelerated, with accelerator pedal released, manual shift is made into second gear. This breaks the circuit on the first and reverse switch, de-energizing solenoid and releasing the diaphragm spring. When the accelerator pedal is released and manual shift made into high gear, a governor switch prevents clutch release above 12 m.p.h. except when the direct speed switch is used. This permits the motor to be employed as a brake when decelerating, and eliminates free wheeling in high except in low speed.

Gear shifting mechanism for the 1941 Buick has the control tube concentric with the steering column mast chassis. The tube is insulated against rattling and has sufficient clearance in lubrication at assembly to prevent binding. The shifting pattern is the same as for 1940. Movement of the shift lever parallel with the steering column actuates a flat rod in the steering column between the control tube and mast chassis and through proper linkage selects the gear. Up and down movement of the shift lever at right angles to the steering column revolves the control tube concentric with the steering column and through linkage to the shift lever on the transmission meshes the gear. Lever ratios are sufficient to provide easy shifting. Freedom from rattles without lubrication is provided through the use of rubber grommets and composition washers along with anti-rattle washer pins and levers. An over-center spring on shift lever assists shifting.







Functionally redesigned, the new Schick shaver, developed by Raymond Loewy in collaboration with Schick engineers, has a larger, more efficient motor and a built-in radio static suppressor. The housing, molded of Beetleware in two parts, has a bead of plastic along the seam to take care of any possible warpage in the plastic material. The fluted lines of the shaver continued on the rubber plug provide continuity in the design. Starting wheel is at rear.

RANDOM JOTTINGS ABOUT NEW DEVELOPMENTS

ONE OF THE LARGEST thermoplastic pieces ever produced in this country is the twenty-six ounce, transparent, methyl-methacrylate front for the Eugene hair dryer, molded at Pittsfield plant of General Electric Company.

* * *

WHEELBARROW TIRES having the advantages of penumatic and solid types have been developed by the B. F. Goodrich Company. New tire, which has a body of cushion rubber, combines lightness, streamlined appearance and low cost, yet has load carrying capacity of a 4-ply pneumatic tire. Punctures are not possible; tire requires no servicing.

SHOCKS AND IMPACTS

In Machinery Having Jointed Elements

FREDERICK FRANZ
Consulting Engineer

BETTER technical definitions of the words shock, knock and impact would be welcomed by engineers, however, no confusion should exist regarding the phenomena accompanying sudden acceleration. In an article in PRODUCT ENGINEERING ("Velocity-Graph Analysis," July, 1940) certain printing-press troubles and their successful correction, were described. The ill effect, called "shake" by its author, of a press was eliminated by reducing the acceleration of the disturbing mass. Yet it was declared that "knocks have nothing to do with the changes of acceleration." The conclusions arrived at regarding the causes of noisy disturbances seem to be illogical. During experiments a knock occurred which was found to be caused by normally alined mating gear teeth becoming misplaced while running, and thus interfering. The misplacements were caused by shaft deflections resulting from forces of acceleration. *Ergo*, all knocks result from misplacement caused by acceleration!

The words shock, knock, impact and impulse can all probably be defined as suddenly applied forces, and sometimes the effects thereof. The forces may be uniform throughout time, or may vary from zero to maximum and back to zero again, or may follow any law during their existence.

Shocks in machinery are generally caused by two or more masses striking each other. To illustrate the usual type of knock occurring in machinery having jointed elements subjected to changes in direction of acceleration, consider what happens in one revolution of an ordinary engine, and for the moment neglect the forces exerted by gas pressure and gravity.

When the crank in Fig. 1 is rising from the bottom of the stroke *B*, and thus beginning to lift the piston the wrist pin clearance is at the bottom. As the rod rises it accelerates the piston. The accelerating force acts on the piston through the pin. The accelerating force on the piston is a maximum at the bottom of the stroke as shown at *A*. Although the velocity upward is increasing, the accelerating force on the piston is simultaneously decreasing, and reaches zero at about the middle of the stroke when the velocity of the piston and of the pin are the greatest, and of course, equal. At position *C*, however, the piston continues rising at undiminished speed in accordance with Newton's first law of motion, while the pin begins to be retarded. The piston runs ahead of the pin by an amount equal to the clearance in the pin bearing and strikes the pin, because, during this interval, the speed of the pin has been retarded according to the kinematic laws of the crank chain.

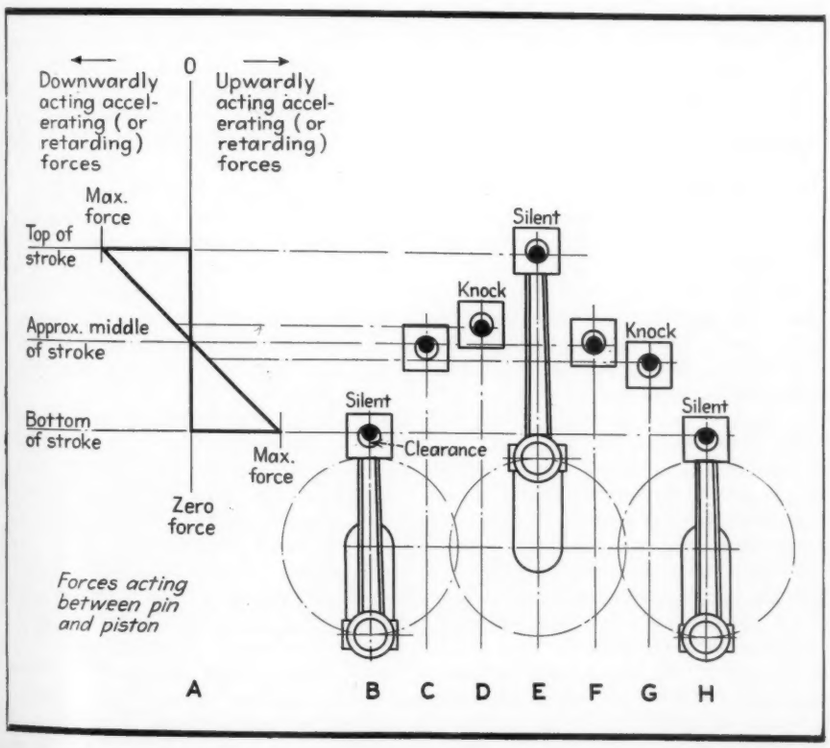


Fig. 1—Acceleration diagram and successive positions of engine piston to show where knock occurs in a loose wrist pin bearing

At *D* the instant of striking the pin, approximately at the center of stroke there is a shock, knock or impact. If there is no auxiliary vibration the pin will now be continually retarding the upward motion of the piston until both pin and piston reach *E*, the top of their stroke. During this ascension from the middle to the top of the stroke, the retarding force acting on the piston has been increasing, attaining maximum value at the top where the motion is instantly reversed. After reversal the accelerating force still acts downward. Note that there is no knock at the top dead center.

The downward velocity of the pin increases while the pin pulls the piston downward until the center of the stroke is reached. Here the acceleration of the pin changes to retardation, the piston runs ahead of the pin, and another knock occurs. No knock occurs at bottom dead center, for the same reason as at top dead center.

The question of what type of acceleration curve to employ at the source of movement, with cams for example, in specific high speed mechanisms should be based upon a study of the clearances in the mechanism and their effect. Mechanisms like crank chains the primary movement of which can not be

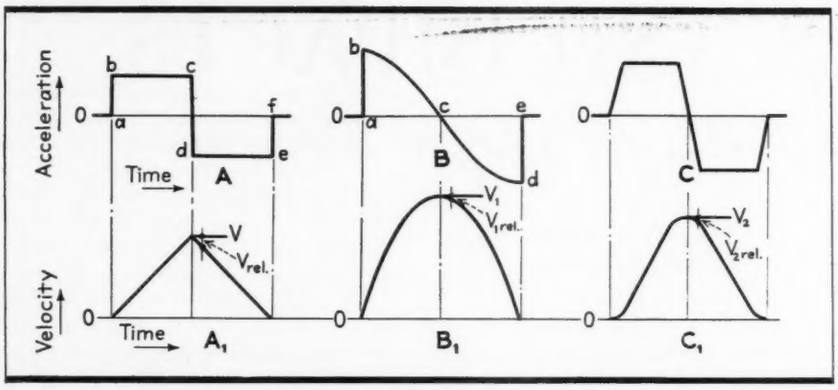


Fig. 2—Acceleration-time curves and relative velocities of clearance impacts for gravity, simple harmonic and cube curves

greatly altered, should be critically studied at all points where changes in acceleration occur.

The object in every instance should be to reduce the velocity of impact in each joint when the acceleration of the mechanism changes the direction, sense or magnitude of the transmitted forces in such a way as to affect the clearance in the joints. This can invariably be accomplished by reducing to a minimum the acceleration (change of velocity) during the time when reversals of the direction of forces occur in the joints of the linkage.

Consider the acceleration-time curves shown in Fig. 2, which are frequently used in connection with cam operated linkages. At *A* is shown the usual gravity curve, which imparts a uniform acceleration to the follower. But note that the force *ab* suddenly acts upon the follower mass at the instant *a*. If this force is great enough it is tantamount to a shock, even though the cam appears to have a "slow," "easy" or "gradual" start, without the apparent sharp corner that is evident at the beginning of uniform rise cams, although the mechanism joints may be tightly fitted. If the acceleration be low enough, the masses of the linkage low enough, the stiffness great enough, and the clearances small enough, no noticeable noise may result. And if the elements are designed strong enough to resist this accelerating force, a successful linkage will result.

But if the magnitude of the acceleration be increased, the masses of the linkage increased, and the stiffness of the linkage decreased, while the clearances be increased, a point will be reached when a noise will be heard. It will be heard as a shock or knock at the beginning of the stroke in the event that the design is such as to allow the cam to take up the clearance and gain velocity before overtaking the linkage. Or it will be heard as a rattle or vibration following the beginning of the motion in the event that the clearances are on the other side and are not first "taken up." The rattle will then be caused by the alternate disposition of the clearances from the near to the far side, as a result of the springiness of the mechanism and the decay of the natural vibrations in the linkage created by the suddenly applied accelerating force. Or noises from both sources may result. This rattle will occur during the time *b* to *c*, Fig. 2(*A*). If the rattle is damped out before reaching *c* another jolt will occur there.

While travelling from *b* to *c*, Fig. 2(*A*), the masses in the mechanism are being uniformly accelerated. At *cd* the acceleration suddenly changes to retardation and the masses are thrown to the other side of their clearances, resulting in a shock.

From *d* to *e*, Fig. 2(A), retardation continues with disturbances similar to those described from *b* to *c*. At *f* disturbances similar to those occurring at *a* may be experienced, depending upon the location of the clearances after the mechanism has come to rest.

The sine curve (simple harmonic motion) for acceleration shown in Fig. 2(*B*) has characteristics similar to those of Fig. 2(*A*). The effect at *ab* is slightly more vigorous because the acceleration must be greater to effect the given movement in the same time as the uniform acceleration, but the effect at *c* is greatly improved. This can be best understood by referring to the corresponding velocity diagrams. Both show that the maximum velocity is reached at the center of the stroke. After passing the center the follower continues with uniform velocity v or v_1, as long as the clearance space is being traversed. It will be noted, however, that the cam velocity at the center of the stroke, in A_1 departs from v much more rapidly than the cam velocity in B_1 departs from v_1. Therefore, when the clearances are overtaken by the cam, the velocity of impact (the blow) will be greater for *A* than for *B*. In A_1 and B_1 the short ordinates v_{rel} and and $v_{1\,rel}$ show the relative velocity of the cam and the follower-mass at the moment of impact.

The cube curve, shown in Fig. 2(*C*), so called because the uniform rate of acceleration part of it results in a cubic equation for the space-time curve, has the advantages of the central part of the simple harmonic curve, at both its center and ends of movement. Shocks at the beginning and ends of its stroke, which result either from clearances or from suddenly applied calculable accelerations can be made less than in the other forms.

Certain reciprocating or intermittent mechanisms such as uniform rise cams, ordinary intermittent gears, spring retracted free masses, non-tangential Geneva motions, and others, are inherently shock-producing elements even when clearances do not exist in their kinematic chain. In these a known mass attains a known velocity with which it strikes another mass. The energy of impact is converted into a force which deflects parts of the mechanism. The product of the deflection and the average force of the blow must always equal the energy imparted to the follower. If for any given blow the force is a measure of the disturbance created, it follows that it is always advisable to increase the deflection and thus reduce the force.

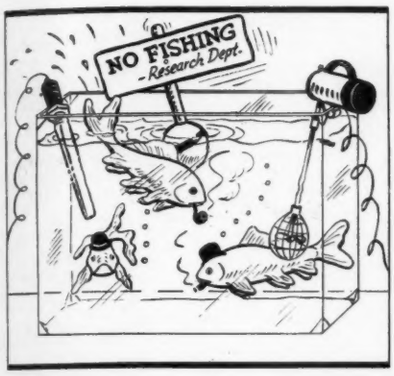
When the sound emitted by a knock is audible, it is usually a noise and not a true sound, that is, it has no recurrent periodic frequencies and rapidly damps out. When shocks or knocks occur at rapid frequency the resulting noise may be called rattle or clatter.

Excessive quivering and vibration of machines when present at only certain speeds and absent above or below those speeds are the result of another phenomenon known as resonance. Because elements of machines have springiness and mass they will vibrate at a certain natural period.

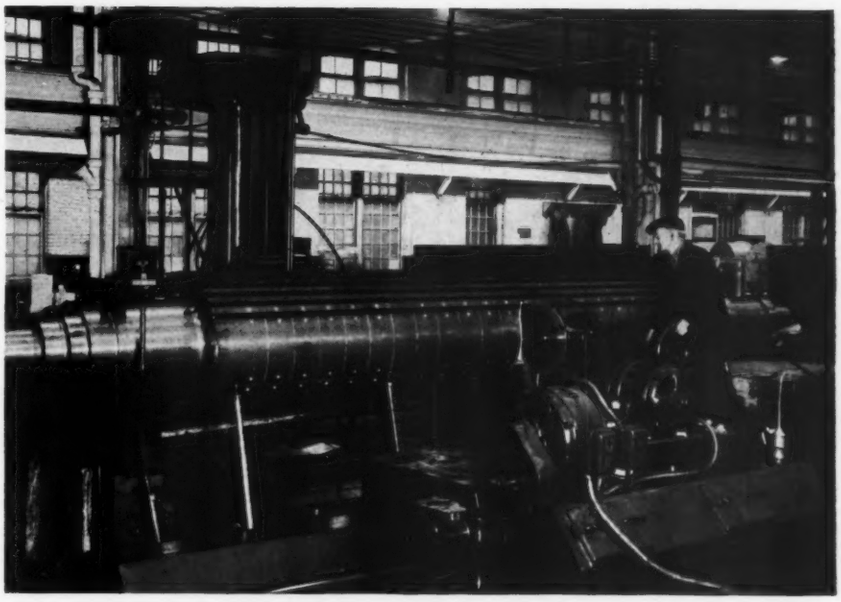
Troubles from knocks in mechanisms are sometimes elusive and defy solution, but a careful analysis of the clearances, masses and stiffnesses of the parts, and a study of their relation to the maximum acceleration or to the points where accelerations change, generally results in a cure or mitigation of the evil. It is safe to say that if mechanism could be constructed with great stiffness and no danger of lost motion, the best form of intermittent motion for fast operating machinery would be instantaneous and maximum acceleration followed by instantaneous and maximum retardation.

CAUSES AND CURES

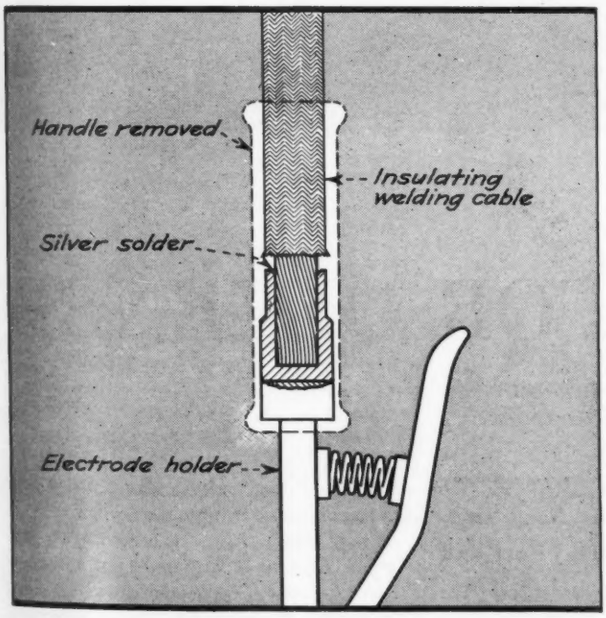
PRODUCT ENGINEERING will pay $3 for each example published in Causes and Cures. Where illustrations are necessary, include drawings, rough sketches or photographs



Scum deposits on the glass walls of a constant temperature bath used in plastic viscosity measurements hindered observations and necessitated frequent cleaning. Engineers finally put three ten-cent goldfish in the bath. Result: no more scum. Even the goldfish seem quite happy about the whole affair.



Vibration of 120 cycles would be caused in this long two-pole rotor for Westinghouse turbine generator by the fact that deep slots cut in opposite sides for field windings have reduced the rigidity on one major axis, thus creating a variation in the sag of the rotor as it revolves. Vibration would be slight, but troublesome to bearings, collector rings and brushes. Cure was to let the rotor sag, but to equalize rigidity of major axes by cutting slots at intervals across unslotted sectors of the rotor forging as shown. This reduced shaft movements from about 0.008 in. to less than 0.001 in.



Excessive heat in an electrode holder handle while arc welding with a ¼-in. diameter rod was causing trouble for the operator. An inspection showed that the soft soldered connection between the holder and welding cable had melted. Naturally, the poor electrical contact built up excessive heat rapidly. The trouble was cured permanently by rejoining the cable and holder with a silver brazing alloy.

SYNTHETIC RUBBERS which are doing wonders in many applications are the cause of trouble in certain uses if operating conditions are not studied carefully and if the properties required of the synthetic rubber are not specified. One designer used seals of a certain synthetic rubber but found that they tended to seize the shafts. A seal made of another type of synthetic rubber proved satisfactory.

MANY FAILURES OF CRANKSHAFTS and crankcases of a new aircraft engine were reported after the engine was put into actual service. Subsequent extensive laboratory tests resulted in no failures, proved nothing. Block tests could not duplicate service conditions. Engineers finally painted brittle lacquer (see PRODUCT ENGINEERING, June, page 266) on the crankcase and crankshaft of several engines which were then flown for various lengths of time. Study of the resulting cracks in the lacquer showed that the engine was not rigid enough. Extreme flexures of the airframe under flight conditions were causing the failures. Cure is still being worked out, but will probably be ribs added to increase rigidity.

Official Photograph U. S. Navy

ENGINEERING FOR DEFENSE

GEORGE F. NORDENHOLT
Editor, PRODUCT ENGINEERING

How the Army and Navy engineers through united effort and with the welcome help of industries, technical societies and educational institutions have standardized designs and specifications for the materials and machinery of war

THOSE who actively participated in the production of arms, ammunitions and equipment for World War I will remember the confusion and delays caused by the engineering designs and specifications. Much of the trouble was blamed on materials specifications. Some were not in conformity with industrial practices, many specifications overlapped or conflicted, and Army and Navy specifications were not coordinated. There were also some out and out mistakes in engineering designs, but when measured in terms of the vast number of drawings that were turned out by the engineering departments for the Army and Navy, the design mistakes were few and far between, and relatively insignificant. However, it cannot be denied that much time was lost and money wasted because Army engineering and Navy engineering were not coordinated and sometimes were not in conformity with the practical requirements and limitations of industry.

Naturally, engineers and laymen alike

are now asking whether the confusion and conflict in specifications and designs that existed during World War I will be repeated. What, if anything, has been done to standardize Army and Navy designs and materials specifications? Are the specifications today more in conformity with commercial industrial production? What is the situation with reference to the so-called "frozen designs" that are mentioned frequently? Is the quality of the engineering designs produced by the Army and Navy good, bad or mediocre? How does it compare with the best engineering produced by industry? What is the situation as to cooperation between the Army and Navy and industry? The answers to these questions are of profound significance. European correspondents have reported that Hitler fears nothing in the world except the power of the American industrial system put to the purpose of producing war materials. Have the Army and Navy engineered, standardized and coordinated their requirements so that American industry will be able to produce at its best?

Unfortunately, numerous recent stories have painted discouraging pictures about the progress in the preparedness program. Some of these stories were obviously based on rumors with embellishments added. Many of them are merely the opinions of laymen who know little or nothing about either engineering or military affairs. Some of the stories and gossip cite conditions that existed during World War I without bothering to mention whether or not the conditions referred to have been corrected. The fact is that in our Army and our Navy we have the finest engineering organizations in the world. They have pooled their knowledge and experience, are cooperating as a unit, and are working with industry and the leading engineering societies to the end that the U.S.A. will possess in a minimum of time the world's most powerful and most effective armaments in quantities far in excess of anything ever produced. And it is being done with an efficiency not even suspected by the average layman.

A complete picture of Army and Navy engineering and how it is functioning can be gained only by a first-hand study of the methods used and by personal contacts with the men who do the work.

The nerve centers for the Army and Navy are the Munitions Building and the Navy Building in Washington, D. C. —two long, white stuccoed, three-story buildings extending along Constitution Ave. from 17th St. to 21st St. Put up as temporary structures in 1916, these buildings house the offices of the Secretary of War, the Secretary of the Navy, and the officers and civilian personnel that direct and coordinate the activities of the Army and Navy. From all appearances, the Munitions Building might be the executive offices of some large industrial organization. One might roam all through it, in offices and along corridors, without seeing a single uniform other than the blue coats and brass buttons of the guards on duty at the various entrances. Colonels, captains, commanders and majors are all in civilian clothes; there is not a trace of military formality and the hum of activity is the same as encountered in any well-organized industrial enterprise.

My first interview in Washington was with Commander A. M. Pride, who heads up the work of preparing coordinated specifications for the Bureau of Aeronautics. Frankly, I was surprised to find him in his office discussing something or other with a man who turned out to be Major D. G. Lingle, who heads up the specifications work for the Army Air Corps. These officers occupy the same office. This was the first of numerous similar incidents that came to my attention to indicate the close cooperation between the Army and the Navy. It was not an "official conference" that these two men were having, but rather an earnest informal discussion of vital engineering problems. As was proved to me repeatedly by similar incidents in the course of interviews with numerous Army and Navy officers, the supposed professional jealousy between the Army and the Navy does not exist, there is not a trace of it.

Another highly important fact is that the men charged with developing Army and Navy specifications are not mere politically appointed officials who do not possess a first-hand knowledge of the needs and requirements of the service. They are all highly qualified engineers, experts in their respective fields; men who have come up through the ranks and have had extensive experience in the fields in which they serve. Commander Pride was a test pilot. Major Lingle was for many years in the engineering section at Wright Field where the designs of new planes are developed, and he also has done considerable flying. These men know aviation in all its branches from design board to stunt flying and fighting tactics. In every instance, I found that the men responsible for Army and Navy engineering have had thorough specialized training and much practical experience.

Major Lingle coordinates the specifications for the Army Air Corps at the Munitions Building, Washington, D. C., and through the Chief of the Materiel Division, Air Corps at Dayton, Ohio, advises and requests tests and investigations to be made by the materials testing engineers at Wright Field, Dayton, Ohio, where all tests are conducted. Similarly, Commander Pride, operating through the manager of the Naval Aircraft Factory, advises and requests tests and investigations to be made by the materials test engineers at Philadelphia. The Bureau of Standards is consulted frequently throughout the whole procedure so that the details of the specifications will conform to established standards of that bureau.

Many civilian engineers, graduates of our leading technical schools and men with outstanding ability and experience, are in the employ of the Army and Navy. Commander Pride, whose immediate superior is Admiral J. H. Towers, is assisted at Washington by Lieutenant-Commander J. E. Sullivan whose staff of civilian engineers includes H. J. Heuster who handles metals specifications, M. T. McCown on textiles and F. F. Jacobs on miscellaneous materials. Major D. G. Lingle reports to the Chief of Air Corps and civilian engineer, F. E. Richardson is his assistant. At the Philadelphia Naval Aircraft Factory, civilian John Hardecker, reporting to Commander Connel, has charge of materials testing; at Wright Field civilian Dr. J. B. Johnson heads up the materials testing and research work under the supervision of the Chief of Experimental Engineering.

To illustrate, omitting extraneous details, the procedure in developing specifications for parachute silk is the same in general as is followed in developing every materials specification for the air services of the Army and Navy. Major Lingle discusses the problem informally with various members of the Air Corps Specifications Committee, of which he is the chairman. Commander Pride also talks over the problem informally with members of the Naval Bureau of Aeronautics Specifications Committee, of which he is chairman. During this time Major Lingle and Commander Pride discuss the problem and map out laboratory investigations and service tests to which the material is to be subjected. The materials test men at Wright Field and at Philadelphia Naval Aircraft Factory are then instructed to develop the specifications entirely independently, using the general instructions merely as a guide for their work.

At both Wright Field and the Naval Aircraft Factory, the materials engineers get to work on the specifications. The assigned group of men conduct laboratory tests, contact textile experts in industry, procure samples of different materials and have test parachutes made. Expert parachute jumpers put the materials through service tests. Weight, strength, durability, moisture absorption and many other factors are

Harris and Ewing

These two "temporary" three-story stuccoed buildings stretching a distance of a half mile along Constitution Avenue, Washington, D. C., today are the nerve centers for all Army and Navy activities. Both the Navy Building in the foreground and the Munitions Building alongside it are now having a fourth story added

determined for a great variety of different fabrics and weaves.

The progress of the work is reported back to Washington. Commander Pride or Major Lingle might recommend additional tests conducted. These are made.

"In fact," said Commander Pride, "I might want Wright Field to make tests to check figures I got from Philadelphia Naval Aircraft Factory. If Major Lingle isn't around, I send my request to Wright Field directly."

To which Major Lingle commented, "Don't I do the same thing when I want something from the Naval Aircraft Factory and you're not around?"

It was just another indication of the extremely close cooperation between the Army and Navy and the informality of the procedure.

When Wright Field and the Naval Aircraft Factory have developed their respective specifications for parachute silk, copies of the specifications are sent to Washington. Major Lingle and his committee sit down with Commander Pride and his committee and go over the two specifications, and from them develop a dummy specification. The dummy specification is a compromise between the Wright Field and the Naval Aircraft Factory specifications. Where those two specifications are the same, the dummy is the same; where they are different, the differences are ironed out in the dummy.

The men from Wright Field and Philadelphia who drew up the specifications are then called to Washington. A meeting is held with these men and the committees of the Army Air Corps and the Navy Bureau of Aeronautics. It is the first, and usually the only, formal and official meeting that is held on this particular specification. Stenographic notes are kept and the meeting is conducted in a strictly parliamentary manner. Commander Pride or Major Lingle serves as chairman. The dummy specification is taken up item by item. All differences are discussed. The rule is that unanimous agreement must be reached on every item. Because specifications are mostly factual, there is little room for opinions.

"But suppose one man has a set idea and refuses to give in?" I asked.

"If a man has a frozen opinion," answered Major Lingle, "the boys keep at him until they thaw him out. The meeting keeps going, with intermissions when necessary, until full agreement has been reached. They usually don't leave Washington until the specification has been completed and accepted. When we're through we have a specification that both the Army and the Navy uses. So far as the Army and Navy is concerned, it is the only Army or Navy specification there is for parachute silk."

This same general procedure has been applied throughout for unifying the specifications for Army Air Corps and Navy Bureau of Aeronautics materials. Practically all of the specifications covering aluminum, aluminum alloys and products made of aluminum are exactly the same for both the Army and the Navy. The significance of this goes far beyond what appears at first glance. It permits bunching of Army and Navy orders. This means more production by industry on a mass basis. Inspection is simplified, possible confusion is eliminated and the quantities of reserve stocks can be greatly diminished.

Of greater significance is the standardization and unification in the designs of Army and Navy airplanes. Great strides have been made. For example, the design of the bomb clips under the airplane wings is exactly the same for Army and Navy planes. Army planes can use Navy bombs, and vice versa. With respect to details such as fuses and powder charge, the Army and Navy bombs must necessarily be different. The Navy bomb for piercing deck plates or serving as a depth charge must of necessity be different from the Army demolition bombs as to timing, fuse and character of charge. But the physical dimensions that affect interchangeability are the same.

Even the engines of Navy and Army ships are interchangeable. The engine mounting dimensions are identical. Any given type, size and make of engines is built to the same prints and specifications, be it an engine for the Army or the Navy. Hence, not only are the engines interchangeable, but the Army and the Navy can use the same spare parts. A Navy plane might have an Army engine that has Navy pistons in it. Thus, the number of spare parts required is only about one-half and a Navy plane can be serviced in an Army shop, or vice versa. And, of course, it means bigger mass production in the manufacture of the engines and spare parts with less machine tools required, less tooling, and fewer gages.

All this has made possible another important move. Within the last month

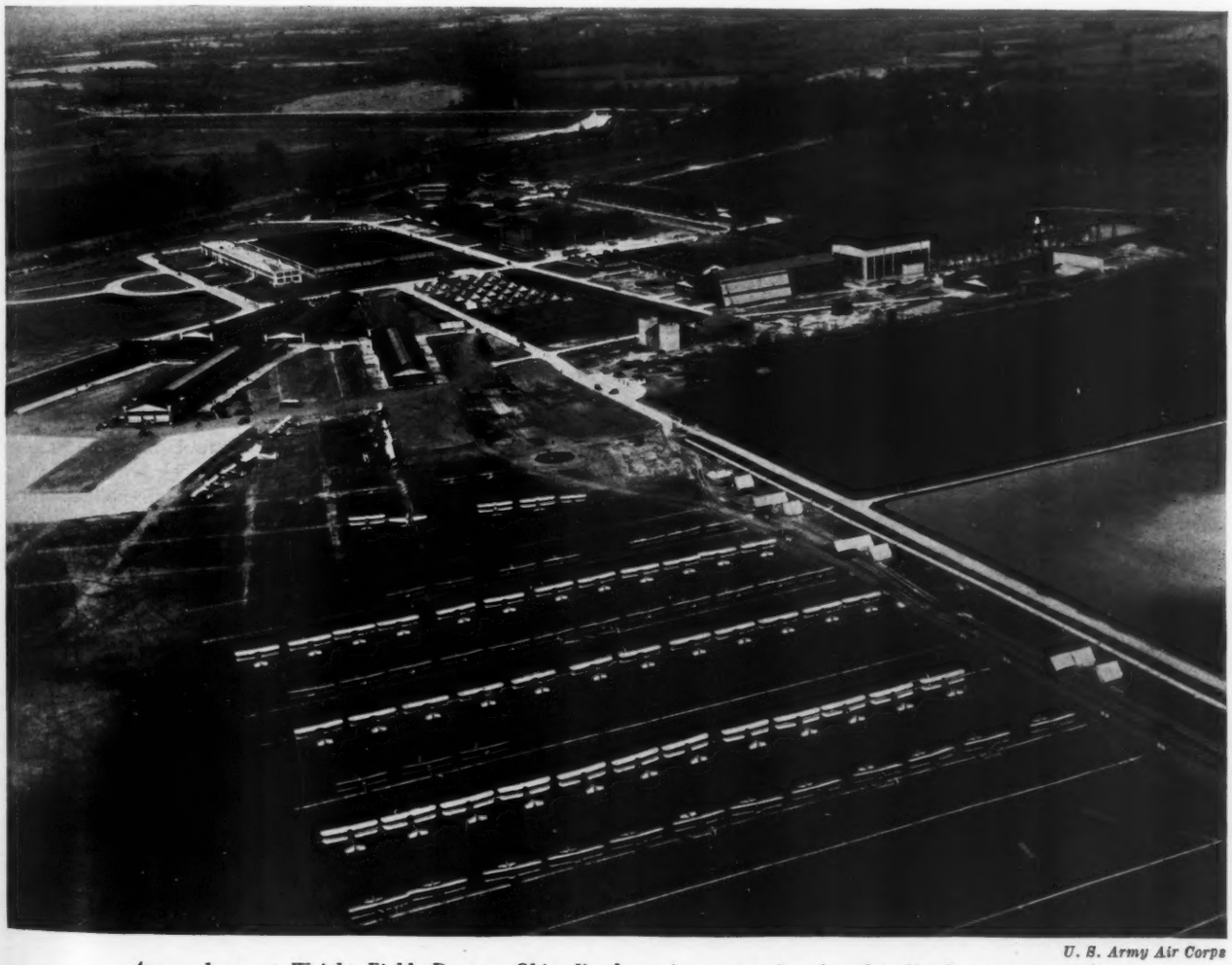
the Army and Navy officially put into effect a new set up for the inspection and acceptance of airplane engines. The manufacture of all Pratt and Whitney aircraft engines, whether they be for the Army or the Navy, will be under Navy inspection and supervision, while all Wright engines for the Army or Navy will be under Army inspection and supervision. This will simplify matters and fewer trained inspectors, of which there is a scarcity, will be needed.

But even this degree of standardization was not enough to satisfy the Army and Navy. Time was the limiting factor. When the National Defense Advisory Committee was organized, William S. Knudsen asked T. P. Wright, vice-president of engineering, Curtiss-Wright Corporation, to serve as aeronautical consultant. Mr. Wright accepted. He knows the problems relating to aircraft production and he is familiar with the needs of the Army and Navy. Also, he always has had close personal contact with officers of the Army Air Corps and the Navy Bureau of Aeronautics.

Army and Navy officers and T. P. Wright held conferences. The question of further standardization of aircraft came up. Both the Army and the Navy were up to their necks in work; there was still work to be done in further standardization of engines and aircraft parts, but no time to do it. But all agreed that if there were any way of speeding the work, it should be done.

For many years the Society of Automotive Engineers, through its various committees, has been doing notable work in the standardization of the design of tanks, trucks, tractors and other automotive equipment for the Army. The membership of that society included most of the country's greatest authorities on engine and automotive design. In his announcement that the S.A.E. had agreed to contribute to the task of standardizing aircraft engines, Mr. Wright said, "The S.A.E. already possesses the system and the machinery for carrying out the job, based on wide experience in carrying through a highly successful standardization program for many years." Of course, without hearty voluntary cooperation between the S.A.E. industry and the Army and Navy, nothing could be accomplished. That this program is already showing results is a significant indication of the splendid cooperation that exists.

When the S.A.E. agreed to actively further the work of standardizing aircraft engines, the society appointed Carleton E. Stryker, well-known aircraft engineer of Bendix Aviation, to the headquarters staff of the society to serve as secretary of the standardization board. The membership of the board, with Mr. T. P. Wright as chairman, includes outstanding aeronautical engineers such as Mac Short of Vega Aeronautical, W. K. Ebel, chief engineer of Glenn L. Martin, Arthur Nutt, president of the S.A.E. and vice president in charge of engineering of Wright Aeronautical, P. B. Taylor, chief engineer of Wright Aeronautical, A. Raymond of Douglas Aircraft, R. W. Ayer of Aeronautical Chamber of Commerce, J. T. Gray of Aircraft, Airworthiness Section of Civil Aeronautics Authority, E. Wells of Boeing Aircraft, J. F. Cox of Vega Airplane, and E. Dudley of Curtiss Aeroplane Division



U. S. Army Air Corps

Army planes at Wright Field, Dayton, Ohio, lined up in preparation for the Air Corps maneuvers

of Curtiss-Wright. Commander Pride of the Navy, Major Lingle of the Army, and J. B. Johnson, civilian engineer for the Army at Wright Field, are among the Army and Navy representatives. This main board supervises the work of many subcommittees, the personnel of which has been selected from industry and the military services.

These committees have already made significant progress in standardizing the airplane engines accessories. As a result, all carburetors, distributors, engine mounts, ignition systems and other accessories will be the same in design for all makes of engines of a given type. Here again, costs will be reduced, production speeded, tooling simplified, and spare parts stocks reduced. Army and Navy orders will be bunched; greater mass production will result. But it could not be accomplished without hearty voluntary cooperation between the Army, Navy and industry.

It should not be assumed that the Army Air Corps and the Navy Bureau of Aeronautics are exceptions with reference to cooperation. Captain Julius Furer a Navy man of many years of service, has administrative charge of all Navy inspection officers and is chairman of the Navy Department Specifications Board, through which are cleared the specifications for all of the bureaus of the Navy, namely, the Bureau of Aeronautics, Bureau of Yards and Docks, Bureau of Ships, Medicine and Surgery, Marine Corps, Bureau of Ordnance and the Bureau of Supplies and Accounts. Each of these bureaus has its specification section and committee and each committee has on it representatives from each of the other six bureaus of the Navy. The Army has a corresponding set up covering its eight branches. Thus every branch of the Navy is kept informed and participates in the making of every specification. Captain Furer's board is also for the purpose of keeping track of the progress being made in the preparation of the fifty or more specifications that are always on the budget. A regular monthly meeting of Captain Furer's board is held for that purpose.

"It is obvious," Captain Furer pointed out, "that this mode of operation cannot work except for the voluntary goodwill and cooperative spirit. Most of the work is done not in committee meetings, but informally and unofficially. There are about 50 specifications going through the mill all the time, and you can readily imagine that little progress would be made if much of the work had to be done "in committee." About the only committee work done is when the committee gets together to pass upon the specification and thus make it official. If we did not operate that way, we never would have been able to develop the 7,000 to 8,000 unified and standardized specifications we now have."

As another example of the close cooperation between the Army and Navy, Commander H. V. McCabe, in charge of Navy Ordnance Specifications and Major J. W. Younger, in charge of all Army specifications, occupy the same office with desks next to each other, and share the same filing cabinets and secretarial service. Major Younger explained that the Army Manual calls for using Navy specifications if the Army has none for the particular material required. And if the Army is getting material from a manufacturing plant where there is stationed a Navy inspector, the Navy inspector tests the material and accepts it or rejects it for the Army.

Wherever possible, the Army and Navy specifications are the same as those of the Society of Automotive Engineers or the American Society of Testing Materials. Army and Navy men serve on practically all of the committees of these two national engineering societies.

So much for the specifications. What about the quality of the engineering design work done by the Army and Navy? With special reference to aeronautics, it is generally acknowledged that much of our progress in aircraft design can be attributed to the Army Air Corps and Bureau of Aeronautics engineers. They are largely responsible for the ultra-high standards of performance of the American fighting and bombing planes. It is they who pointed the way to innumerable design improvements and refinements in manufacture.

The minimum acceptable performance for an Army or Navy airplane engine is 300 to 400 hours of running before a major overhaul is required. Many of the engines run 900 hours before a major overhaul is required. According to observers at the war fronts, the average life of a German aircraft engine is 50 hours in combat. To overhaul an airplane engine is almost half as much work as building it originally.

In the performance of airplanes the U.S.A. has the fastest pursuit ships, the longest range and largest bombers, and the armaments on the planes, including power operated gun turrets, are of designs far more advanced than those of any other nation. Our bomb sights and navigation instruments are the envy of all other nations. Such progress would have been impossible without highly efficient engineering and splendid cooperation.

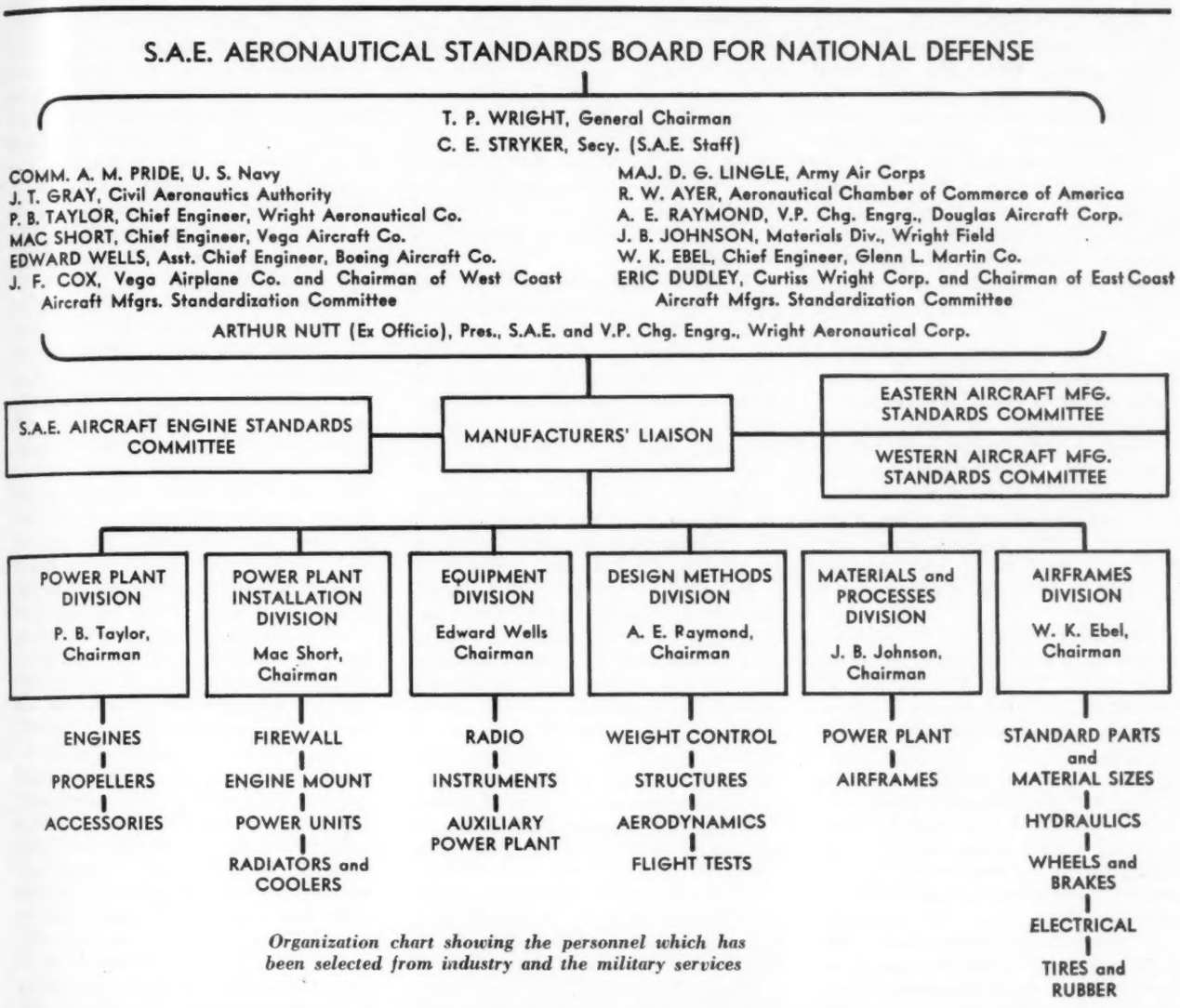
Recently there was a rumor to the effect that the Chrysler Corporation, after accepting an order for medium weight tanks designed at Rock Island Arsenal, had to put 100 or more engineers on the job to redesign the tank and correct all the mistakes. The falsity of that rumor can be matched only by its stupidity. It reflects a complete ignorance of the procedure by which tanks, and all other armaments, are designed.

At the Aberdeen Proving Ground of the U. S. Army at Aberdeen, Md., tests of tanks and other armaments are under way continuously. Maneuverability of the tank is studied carefully, as are its armor plate, guns, speed, and all other factors. Detailed reports of the functioning of the tanks in war maneuvers are made by tank corps officers. Observers on foreign battlefields report on performances of tanks in actual battle and make note of things such as failure by bogging down, insufficient armor, vulnerability of the engine or mechanisms. At the same time, officers and civilian engineers at Rock Island Arsenal study new design possibilities opened up by engineering and technological progress.

When it is decided that a new design of tank is to be undertaken, all the officers and civilians who have been studying tank design are called to Washington. At the Army headquarters in the Munitions Building they meet to map out the new tank. The tank corps officers, test engineers from Aberdeen, the officers who have been on duty as foreign observers and the engineers from Rock Island Arsenal gather around conference tables and drawing boards. Evidence of deficiencies in existing designs and desired improvements and new features are studied and discussed. It is an engineering development meeting rather than an ordinary conference, as triangles and T-squares are put to use and the general outline of the proposed tank is drawn to scale and overall specifications such as weight, speed, power plant and protecting armor plate are drawn up.

The proposed design is then delivered to Colonel N. F. Ramsey, commander of Rock Island Arsenal, who turns the job over to Mr. Frank Hargens, civilian chief ordnance engineer at that arsenal. Backed by 25 years experience and a corps of some 200 well-trained engineers and draftsmen, Mr. Hargens sets to work to produce the seven or eight thousand drawings required. Tentative designs are made and remade. Various arrangements of the tank machinery, different types of construction, and a myriad of different details are tried, studied, discarded or accepted. Slowly the picture develops and finally, after many months of painstaking effort the first design is completed; but that is not final.

Mr. Fred Hoppe heads up all the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FLIGHT TESTS
POWER PLANT
AIRFRAMES
STANDARD PARTS and MATERIAL SIZES
HYDRAULICS
WHEELS and BRAKES
ELECTRICAL
TIRES and RUBBER

Organization chart showing the personnel which has been selected from industry and the military services

work of specifying the materials. Army specifications are used where available. In their absence, Navy specifications are used. If it is a special material and there are no specifications, Mr. Hoppe calls in experts from industry and prepares tentative specifications.

Captain C. R. Pinkerton has charge of the automotive production and also the research laboratories. Civilian Paul Cunnick directs the materials testing laboratory, working closely with Mr. Hoppe and the engineers representing the suppliers of materials. Indicative of what has been accomplished, whereas formerly 25 different alloy steels were used in a tank, today only 14 alloy steels are specified.

After the proposed design has been completed it is sent to Washington and the experts of the Army subject it to a critical study. Changes may be suggested. Eventually this preliminary design is approved and the Rock Island Arsenal shops are given the order to produce a sample tank for tests.

Under the direction of Colonel C. A. Waldman and assisted by Captain Pinkerton and an organization of highly skilled machinists and mechanics, the sample or "pilot" tank is built. As each and every piece is made it is given a close inspection to make certain that it conforms to the drawing in every detail. If it does not, a new piece is made or the mistake is corrected. But every piece must be exactly to the drawing. If later, when the pieces are being assembled, a part does not fit, the inspectors determine what is wrong. If the mistake is in the drawing, the drawing is corrected and then, but not until then, a new corrected part is made. Obviously, when the pilot tank is finished, the drawings must be right.

The sample tank is sent to the Aberdeen Proving Grounds and "put through its paces" under the critical eyes of experts. Every detail is scrutinized closely. Could the tank be made slightly lower in order to present a smaller target, could it be made slightly shorter and thus increase its maneuverability, is the armor plate thick enough, could the tank be made a little lighter or given wider tread so that it will not bog down as readily? These and hundreds of other possibilities are carefully considered. Always the demands of these test men appear to be just a little more severe than engineering can meet—but usually the engineers "come across."

Indicative of the amount of engineering involved, when it was decided to increase the thickness of the armor plate on a recent design of tank, it required 60 days of engineering to make all the necessary changes in the thousands of drawings affected and then to carefully check and recheck every change.

Little wonder that Mr. Fred Zeder,

hard hitting and critical vice-president in charge of Chrysler engineering, said "Chrysler takes second place to no one in engineering, but I must admit that if we had the boys at Rock Island Arsenal to add to our engineering staff we would materially strengthen our position. They could teach us a lot about center of percussion and what makes a vehicle run smoothly. I never dreamed that a big heavy tank rolling over rough ground at 40 miles per hour could ride so smoothly."

Mr. Zeder was referring to the rumor that Chrysler engineers had found it necessary to redesign the tank designed at Rock Island Arsenal and to be manufactured by Chrysler. He explained further:

"Rock Island Arsenal sent us one complete set, 186 pounds, of drawings and we sent them to our pattern shop. Every piece was made out of wood and the pieces were then assembled. There wasn't a mistake, not a single mistake, in the more than 6,000 drawings which we received.

"We then put about 200 engineers on the job to make a complete production study of the tank. They detailed all the operations, listed all the manufacturing equipment needed, and laid out the shop."

Apparently, some layman who knew little or nothing about engineering procedure, had heard that many Chrysler engineers were working on the Army tank. He drew the conclusion that they must have been put on the job to correct mistakes; his limited knowledge could not visualize that there might be other engineering work to be done. That is the way many of our present day rumors criticizing the defense program start.

Much more could be written about the Army and Navy organization for the standardization of designs and specifications. There are the numerous joint boards such as the Joint Army and Navy Munitions Board, the Joint Smokeless Powder Board, the Joint Gun Forgings Board, and several others. Each is for the purpose of unifying Army and Navy engineering. And of great importance is the Federal Specifications Executive Committee.

Organized early in the nineteen-twenties, the purpose of the Federal Specifications Executive Committee, then called the Federal Specifications Bureau, is to coordinate and unify all specifications that are used by three or more government agencies. The Army and Navy use Federal Specifications whenever applicable. Not only the Army and the Navy, but all other agencies such as the Post Office Department, Department of Agriculture, Veterans Bureau and all other government departments are served by the Federal Specifications Executive Committee, which is made up of representatives from all the government agencies served and many men from the Bureau of Standards.

The work of the Federal Specifications Executive Committee is divided into numerous sub-committees, each handling certain classes of materials. The biggest of these is the Metals Committee.

In about 1922, because of the vast job of developing metals specifications, the Ordnance Metallurgical Advisory Board was organized, which in August 1940 was divided into the Ferrous Division and the Non-Ferrous Division. Colonel R. W. Case of Watertown Arsenal is chairman of the Ferrous Division and his associate, Lt.-Colonel S. B. Ritchie, is recorder. The Non-Ferrous Division is under the chairmanship of Colonel W. P. Boatwright, commanding officer of the Frankford Arsenal, and Captain L. S. Fletcher of that arsenal is recorder. Captain D. J. Martin of the Office, Chief of Ordnance, serves as a member. All other members of those two committees are civilians, experts and outstanding authorities. Included are Dr. F. C. Frary of the Aluminum Company of America, Dr. D. K. Crampton of Chase Brass, W. B. Price of Scovill Manufacturing Company, Sam Tour of Lucius Pitkin, F. P. Gilligan, metallurgical consultant for Henry Souther Engineering Company, Paul McKinney of Bethlehem Steel, Robert Archer of Republic Steel, G. Elkins Knable of Carnegie-Illinois, John Mathews of Crucible Steel, Dr. C. H. Mathewson of Yale and H. S. Rawdon of the Bureau of Standards. All are prominent metallurgists and men who know the practical requirements of industry. They serve without pay; their respective companies contribute the services of these men and pay their expenses.

So well organized is the engineering of the Army and the Navy, so effectively do they cooperate with each other, with industry and the national engineering societies, that there is little or nothing that can be done to improve it.

It is significant that after a two weeks investigation by a high government agency to find out what could be done to expedite the engineering work of the Army and Navy, the verdict rendered was, "Nothing, absolutely nothing. The machinery for operating is all there, it is functioning with the greatest satisfaction, it is manned by a highly efficient personnel with a wonderful spirit of cooperation."

Much more could be written about the engineering work of the Army and Navy. The work of the Federal Specifications Executive Committee, the contributions of the Bureau of Standards, and the work of the Welding Research Committee of the Engineering Foundation, under the chairmanship of Colonel G. F. Jenks, are each a story in itself. It would require many pages to describe the great work that the National Advisory Committee on Aeronautics is doing. And still the story would be incomplete. At some of our leading technical universities research work of great value to the Army and Navy is being carried on under the joint sponsorship of the Army, Navy, the N.A.C.A. and the Engineering Council.

I feel certain that in my weeks of interviews I had uncovered but a small fraction of the facts and figures concerning Army and Navy engineering. I had been treated most cordially and I had made the acquaintance of many fine men. Time finally compelled me to consider this assignment finished, and it was with sincere regret that I checked out and took a cab to Union Station.

As I entered Union Station something impelled me to look back. In the distance the flood-lighted dome of the Capitol stood out against the dark sky. And there came over me a feeling that what I had seen and learned was not a mere organization chart and a description of its operation. All that I had seen and heard was merely the external evidence that the brains, skills and energies of men of the Army, Navy, industry, engineering societies and educational institutions are being applied with a unity of purpose to the end that American Industry, the world's greatest production machine, shall and will produce in super-abundance, armaments the like of which the world has never seen—armaments that will hold safe the Democracy that the flood-lighted Dome of the Capitol symbolizes. Guiding this far-flung engineering undertaking are the officers and men of the Army and Navy, operating as a unit. These are the men upon whose accomplishments depends to a great extent the future of this nation. And they are doing their job well—very well.

Standards

Designation numbers for Federal, Army, Navy, S.A.E. and A.S.T.M. Standards covering various types of aluminum and magnesium products are listed on pages 535 and 536 in parallel columns for easy reference and comparison.

IDEAS—*The Essence of Development*

C. M. ASHLEY
Product Development Engineer, Carrier Corporation

IDEAS are the stuff from which new designs are spun. Everyone has had ideas, has put ideas into practice, and has listened to the ideas of others. Yet few people ever stop to consider just what an idea is. Its nature is generally misunderstood. For instance, it is commonly supposed that the number of ideas is limited, at least concerning any one subject, and that only a few persons are endowed with the mystic genius of idea creation. This is not so. Consider Rube Goldberg and his ilk and it is apparent that ideas can be legion.

Ideas are the impingement of imagination on experience. As such there is nothing mysterious or exclusive about their origin and there is no reason why anybody should not have them. They are likely to be original with one person to the extent that his experience or imagination is in advance of that of others. But ideas are the property of no man and are as free as air to those who would seek them.

What does distinguish some ideas from others is the directness and simplicity with which they reach their objective. The question is not "How can an objective be reached?", but rather, "How can it best be reached?" This point of view very evidently strips ideas of any inherent value. They retain value only as they are useful. By the same token, no particular credit redounds to the person who has an idea. Credit is due only to him who has a good idea.

There is no mental quality that permits anyone intuitively to select good ideas and only good ideas. Therefore, the problem of arriving at good ideas is one of elimination. This involves, in the first place, marshalling all of the ideas which can be conjured up on the subject. There is no reason why this procedure should not be orderly. After a little experience the ideas can be classified and all of the permutations and combinations exposed to view. The second step is to submit the various ideas to critical analysis.

Of the two steps, the second is the more difficult. One must be sure on the one hand that no hidden possibility is passed over lightly, and on the other hand that time is not wasted exploring unprofitable alloys of ideas. The quantitative attitude of approach toward this analysis is most valuable as it will eliminate the great mass of ideas which are qualitatively practical but quantitatively impractical.

An attitude which must be repelled is the proprietary one. It makes an idea no better just because I happen to have thought of it rather than you. It must derive its value without respect to who conceived it. Since the value of ideas can be proved by practice, it behooves each individual to see that his ideas are used only when they are superior to the ideas of others. There is always a suspicion that a person may not take an objective point of view in comparing his ideas with those of others. For this reason, it is frequently wise to get the opinion of some competent, disinterested person.

Harris & Ewing

People thought both of these ideas were ridiculous, but the one above was sublime. Knowing when not to laugh an idea out of existence calls for acute foresight and sound engineering judgment

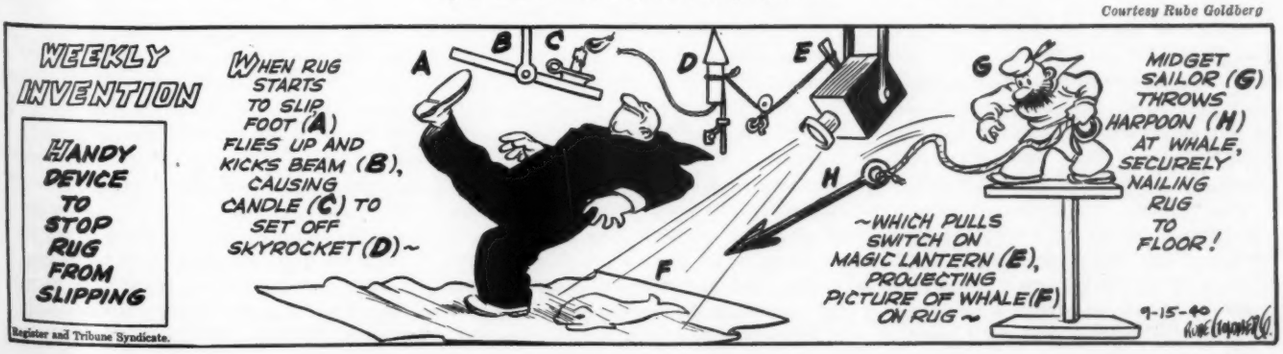
It frequently happens that an idea has to be presented in the proper form, that is, "sold" to the person with the necessary authority. It is not fair to suppose that ideas have self-evident merit which should immediately impress a superior, even when he is very receptive. On the other hand, it is important that the idea not be misrepresented.

Novelty

At first thought it might seem that a new design must have a great deal of novelty to be really valuable or worth while. The new, the miraculously different seems to be the thing which makes the headlines and attracts the attention. Yet how many times is the article which is radically different from all competitors the sales leader? Not many. True, when the advantages are clear and self-evident, then sales may flow to the novel product. But it lacks the mutual sales help of competitors which are much alike. A good example of this is the steam automobile. Basically a much simpler and more flexible machine than the conventional type, its patent protection and uniqueness proved its undoing.

Look around and consider how many things of a mechanical character which are considered indispensable represent the simplest, most dramatic approach to the problem. Then consider the vastly larger number of things which are the fruit of years of polishing what may basically be a very impractical idea. The automobile is perhaps the perfect example of this. Rube Goldberg himself could hardly have conceived of the

Courtesy Rube Goldberg


WEEKLY INVENTION
HANDY DEVICE TO STOP RUG FROM SLIPPING
WHEN RUG STARTS TO SLIP FOOT (A) FLIES UP AND KICKS BEAM (B), CAUSING CANDLE (C) TO SET OFF SKYROCKET (D)~
~WHICH PULLS SWITCH ON MAGIC LANTERN (E), PROJECTING PICTURE OF WHALE (F) ON RUG~
MIDGET SAILOR (G) THROWS HARPOON (H) AT WHALE, SECURELY NAILING RUG TO FLOOR!
A
B
C
D
E
F
G
H
9-15-40
Register and Tribune Syndicate.

automobile transmission, clutch or ignition system. Before the automobile of today could be perfected it was necessary to establish and develop whole new industries, such as that of alloy steels. Every important part is the result of years of effort to achieve the best possible result without any fundamental change which would affect too many other parts.

Most progress in the line of machines comes as a gradual evolution of an existing type. There comes a time, however, when a radical departure must be made from previous forms if further progress is to be made. The new type is usually the survival of a whole series which have been tried and discarded. Naturally this process is expensive and is usually left to the little fellows who do not have much of a stake to lose. On the other hand, it pays every company to keep informed of progress and trends and occasionally to make a "scoop" by bringing out an advanced design.

What philosophical attitude can we have toward novelty? First, we can stop chasing will-o'-the-wisps; we can look to the present forms and study them to see how they can be made more perfect; we can accept something which may never reach the heights of ultimate perfection and refine it in detail to make it a highly workable design. Second, we must keep before us the ideal of a design which will not have the inherent limitations of the present type; we can and must be dissatisfied with present forms, striving for a simpler and basically better form. Third, we must appreciate the problems inherent in the attainment of the simpler form; the long search, the slow perfection to a usable state, the breaking down of commercial and psychological barriers to its use.

Selling the Idea

Equipment design and selling would seem to be as far apart as the poles. Nevertheless, there are times when the development man can serve his company best if he has the ability to "sell" his ideas to his superiors. It is a common belief that new ideas originate in the sales force in the field from whence they flow back to the development department, which puts them into workable form. Actually, this is seldom the case. The salesman must take a somewhat uncritical attitude toward the equipment which he sells in order to maintain his selling integrity. Naturally, he glosses over imperfections as long as possible.

On the other hand, the imaginative designer is painfully aware of the deficiencies of his design, even though he is not permitted to give voice to them publicly. More than that, he visions a product not only better in detail, but in basic conception as well.

The engineer need not take the role of the partisan in his presentation. His job is to show the relation of his ideas to others which might be considered. He should assume the attitude of an advocate only long enough to obtain recognition for his ideas, then he should revert to the judicial point of view. Often it is better to unfold the picture gradually, over a period of time, through the medium of periodic suggestions. It frequently takes time to change mental patterns to meet new suggestions. But by means direct or devious, the engineer must somehow present the picture of the future in compelling terms.

Ideas and Organization

A development program must be organized in one of two ways; either one man or group must carry it through from beginning to end, or it must be passed successively from one specialized group to the next until it is finally completed.

For one man to carry on a project from beginning to end with success requires a most rare combination of abilities. It is an axiom that no man is at once a good beginner and a good finisher. To launch a development needs a man of boundless imagination. He should be able to think of all of the ways under the sun of doing a thing. His mind should range through all the possible and impossible ideas for accomplishing the desired end. Sometimes he will be able to distinguish between the possible and the practical. Often this must be done by someone with his feet more firmly on the ground. But even the "crackpot" inventor has his place at the beginning of a development.

Once the development passes its initial phases, however, this type of man usually loses interest. In his imagination it is already complete and perfect and his interest seeks out still other ideas. Such a man has not the patience to guide the development through its slow perfecting stages.

Here is needed a "hound" for detail, who can take all of the "kinks" out of the design, who can sharpen his pencil and whittle first dollars and then pennies out of the cost. He must be willing to prove the practicability of each part and of the whole design by exhaustive laboratory tests and field trials. Frequently, before the development is turned out as complete, quite a number of people must each take a hand in it in succession. More often than not the tooling and the introduction to manufacture is handled separately.

When one man is in a dominant position with respect to a development, he leaves the stamp of his personality upon the design. His weaknesses may be as evident as his strong points. Why then should carrying on the development under one man be considered? Because the other alternative is equally dangerous. When a design is passed on to a new group, something is lost in the transfer. Frequently the new group may approach the design from an entirely new point of view and lose much that was of value in the original design. The people dominating each step are likely to have their own pet ideas, which may find their way into the finished product to its detriment.

It is evident that there is no "royal road." Regardless of the method of organization, the project must depend for success upon the ability of the people who are to carry it on. Also, there must be no insulation, no barriers between the men or groups carrying on the development; each must be subjected to the same ideas and the same criticisms. This naturally indicates that there must be a common leader throughout the progress of the design.

How, then, are the disadvantages of this type of organization to be overcome? Most important of all, the leader must understand himself. He must know where his strength lies and where his weakness; where he can rely largely on his own judgment and where he must call on that of others. He must gather around him men who will complement his abilities in order to form a well-rounded group. He must know when to call for help outside of his group. Furthermore, this leader, by understanding his point of weakness, can gradually train himself to a rounded ability more nearly approaching that of the ideal development man. He can also learn a tolerance for diverse points of view which can contribute to the success of the development and can learn to accept even though he cannot sympathize with them.

There are, of course, many able men who, because of a too great one-sidedness or because of an insulation from the point of view of others, can never become leaders.

The administrator to whom the leader reports must provide a point of view which balances that of the leader. He must also see that the leader is surrounded by adequately complementary assistants. Thus, one of the most important aspects of the organization of development work is to study and train the aptitudes of individuals in order to fit them together into harmonious and well-rounded groups capable of carrying through a development from rough idea to finished product.

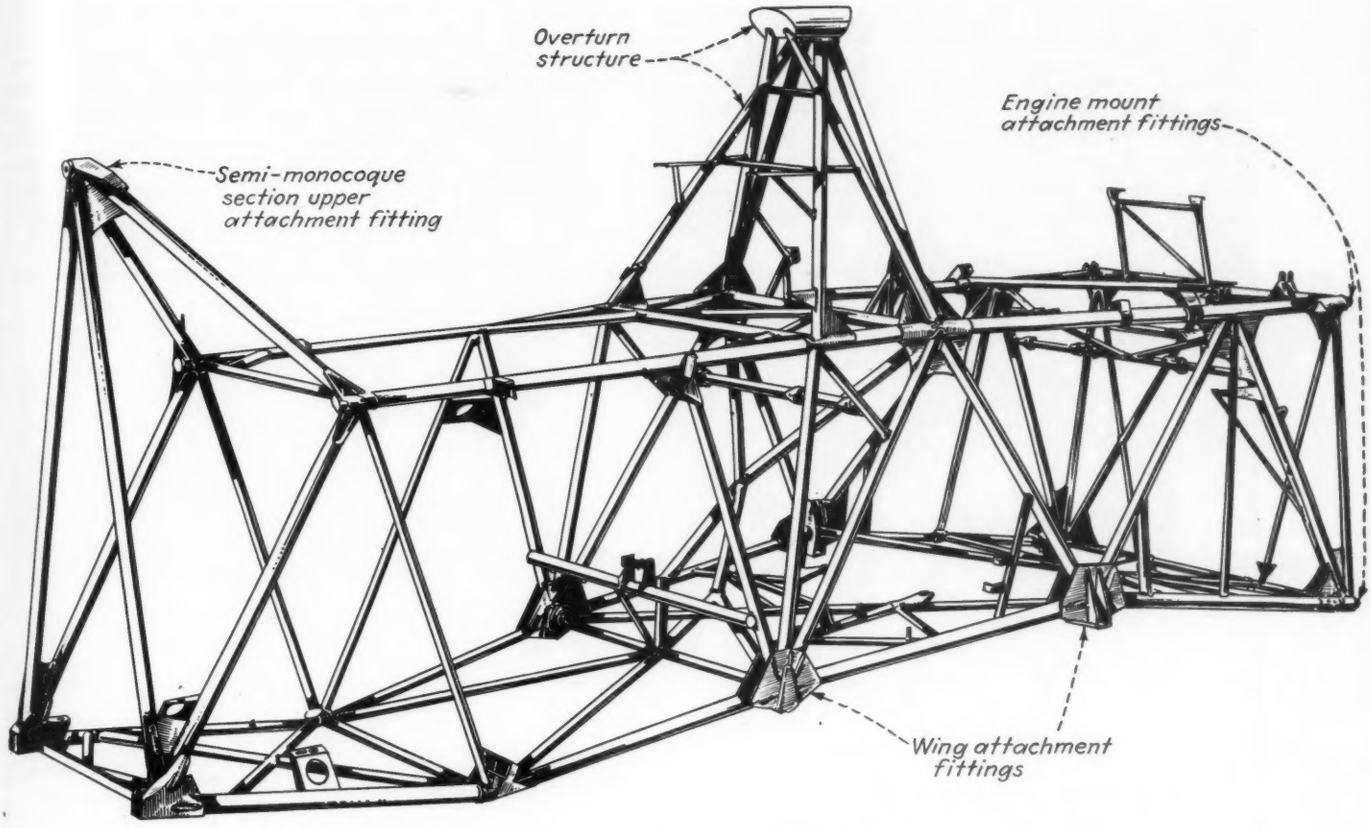


Fig. 11—Steel tube section of a composite fuselage, showing major fittings

STEEL TUBE FUSELAGES—II

Major Fittings and Joints

JAMES E. THOMPSON and T. A. LOWE
Vultee Aircraft, Inc.

IN the first part of this article basic layouts of steel tube fuselage structures were considered from the viewpoint of production design. Layout of tube center lines is actually the first step in the design of any tubular structure. The next step in design is determination and location of the required major fittings and joints for engine mounting, fuselage sections, and wing and empennage attachment to form the complete airframe. These major fittings and joints will be considered in this section, illustrated with practical, proved designs. Production designs for an overturn structure suitable for an open cockpit airplane are also shown, as are empennage and tail gear attachment methods for an all-steel-tube fuselage structure. Locations of major fittings are shown in Fig. 11, above.

Engine Mounts

A majority of present-day engine installations are for radial engines. This type of power plant permits simple engine mount designs, which basically comprise a steel tube ring connecting to the engine mounting lugs. Four V-truss steel tube members welded to this ring are each provided at the apex with a fitting for connection to fuselage longeron.

General design considerations for radial engine mounts are shown in Fig. 12. An engine mount in a drill jig for location of attachment holes after welding is shown in Fig. 13; at the right is the same mount completely fabricated, drilled, machined and ready for installation on the fuselage. It should be noted that the layout geometry of engine mounts

of this type is based upon having all tube center lines converging at joints, where practicable.

Junctions of ring and tubes should not be located directly at engine attachment fittings. This will permit planar alignment of the fitting faces by local heating after welding. This is especially desirable if a fairly high tolerance can be allowed on the planar alignment of these fittings—in the order of ±0.010 inch. A generous tolerance will permit final sizing of the fittings prior to final welding, which will greatly facilitate production by avoiding handling of the complete assembly during machining operations.

When close tolerances are required on planar alignment, such as ±0.002 inch, it may be necessary to complete final sizing, facing and reaming of fittings after the completion of welding. The complete assembly must be handled during these machining operations, increasing production time since the large bulky form of the complete engine mount is awkward to handle.

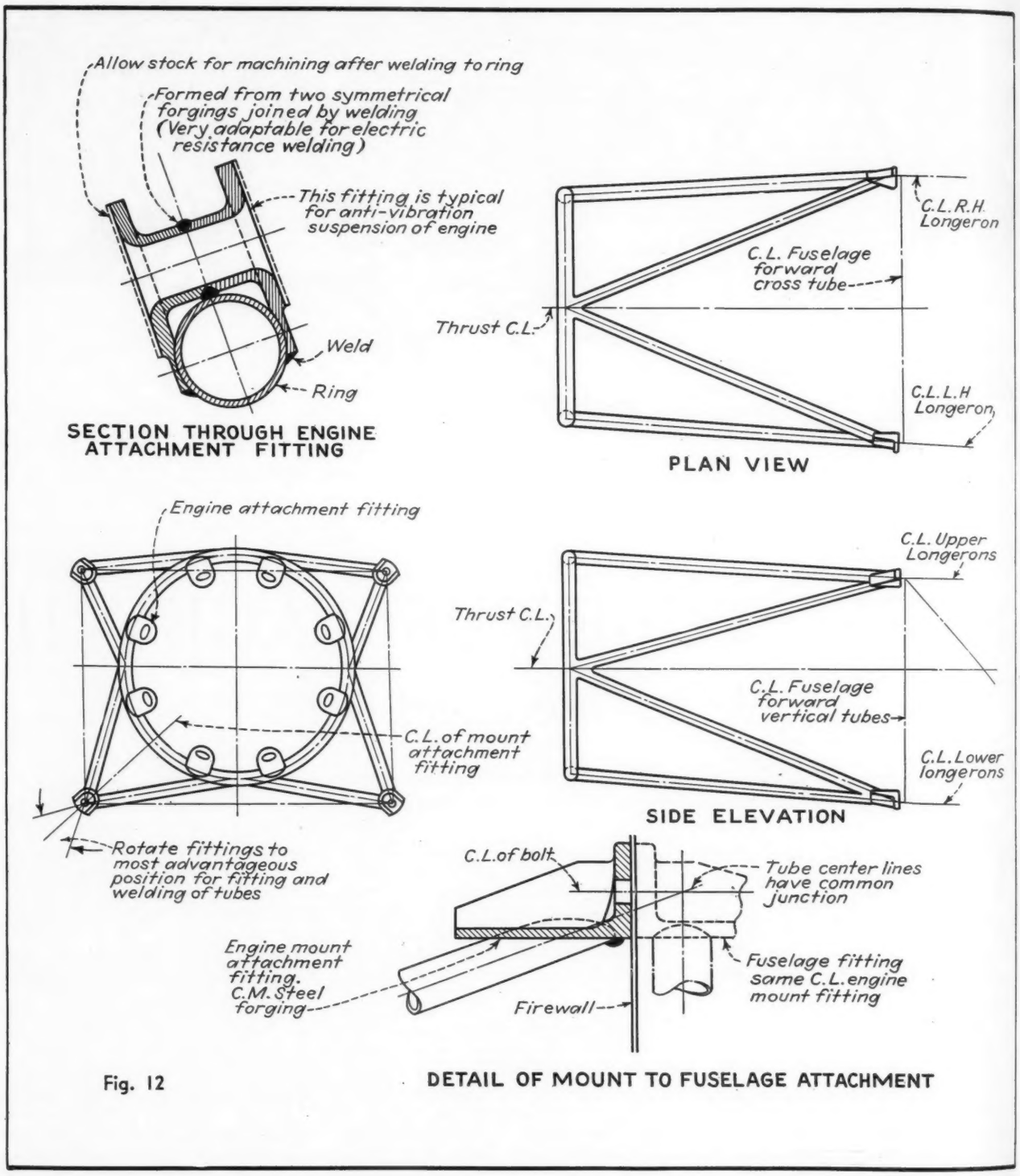

Allow stock for machining after welding to ring
Formed from two symmetrical forgings joined by welding (Very adaptable for electric resistance welding)
This fitting is typical for anti-vibration suspension of engine
Weld
Ring
SECTION THROUGH ENGINE ATTACHMENT FITTING
C.L. R.H. Longeron
C.L. Fuselage forward cross tube
Thrust C.L.
C.L. L.H Longeron
PLAN VIEW
Engine attachment fitting
C.L. of mount attachment fitting
Rotate fittings to most advantageous position for fitting and welding of tubes
C.L. Upper Longerons
Thrust C.L.
C.L. Fuselage forward vertical tubes
C.L. Lower longerons
SIDE ELEVATION
C.L. of bolt
Tube center lines have common junction
Engine mount attachment fitting. C.M. Steel forging
Fuselage fitting same C.L. engine mount fitting
Firewall
DETAIL OF MOUNT TO FUSELAGE ATTACHMENT

Fig. 12

Fig. 12—General design considerations for radial engine mounts built up from steel tubing

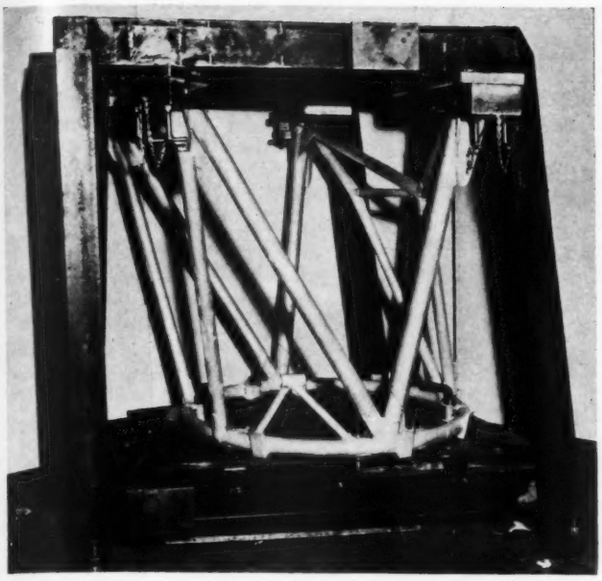


Fig. 13—Radial engine mount in tool jig

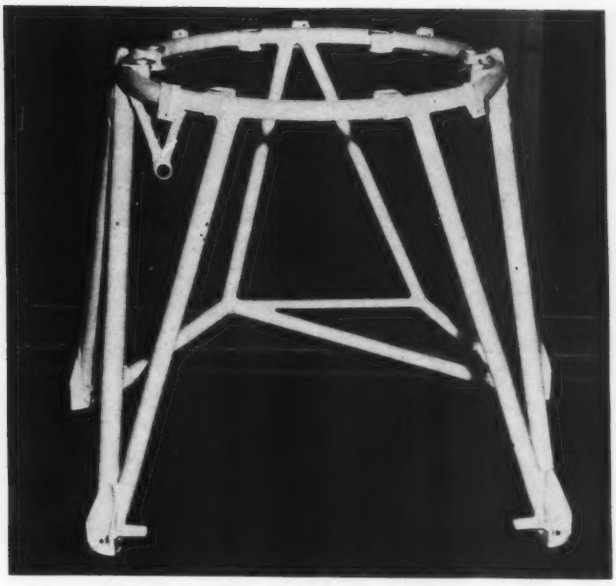


Fig. 14—Completed mount with machine gun support

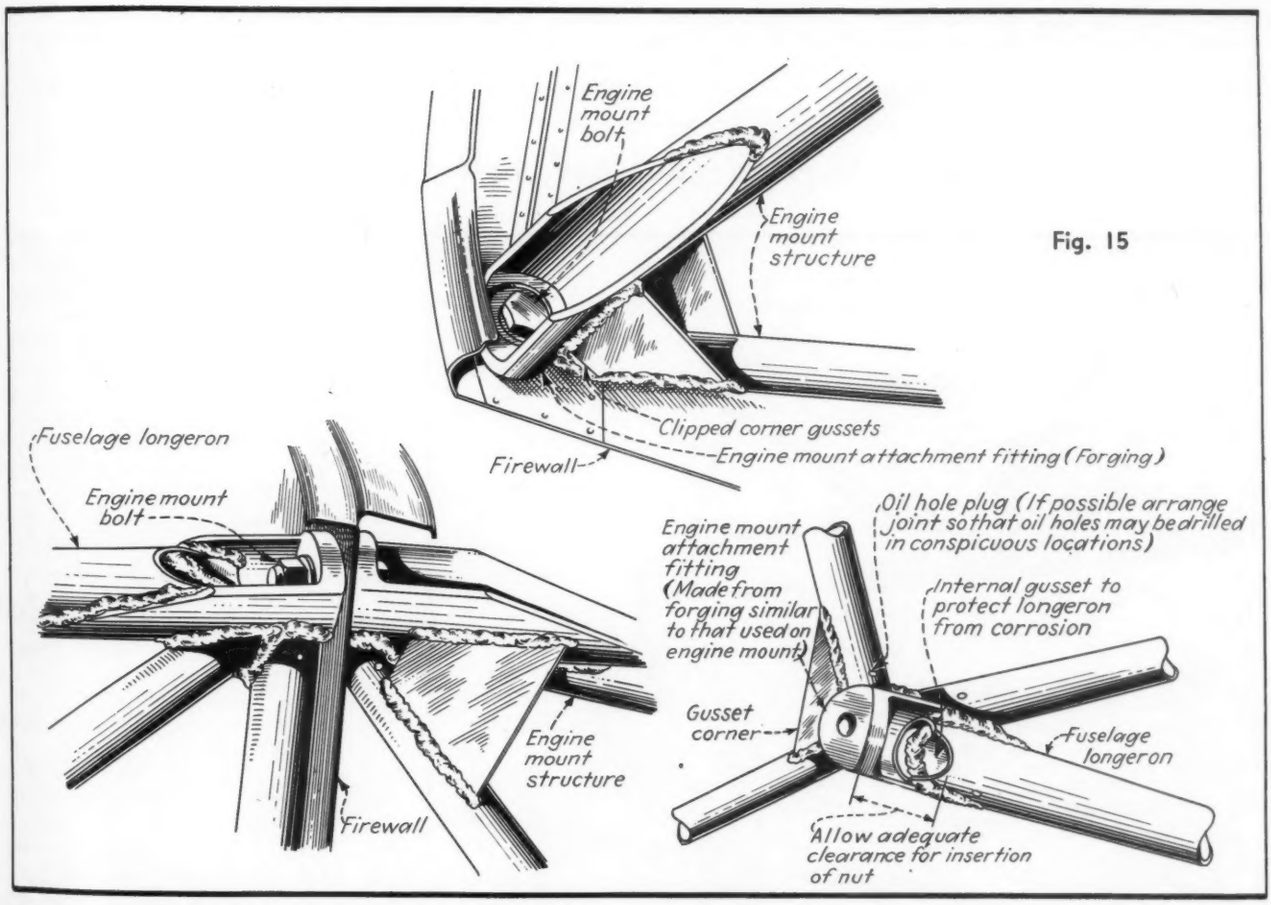

Engine mount bolt
Engine mount structure
Clipped corner gussets
Engine mount attachment fitting (Forging)
Firewall
Fuselage longeron
Engine mount bolt
Engine mount structure
Firewall
Oil hole plug (If possible arrange joint so that oil holes may be drilled in conspicuous locations)
Engine mount attachment fitting (Made from forging similar to that used on engine mount)
Internal gusset to protect longeron from corrosion
Gusset corner
Fuselage longeron
Allow adequate clearance for insertion of nut

Fig. 15

Steel forgings for engine mount attachment fittings are standard practice and their use lends itself well to economical production. The obvious objection to the use of forged fittings is that the walls to which the tubes are welded must be fairly thick in order to prevent the forging billet from chilling before the forging operation can be finished. Thus the forging walls are usually heavier than required for the stresses involved and are much heavier than the walls of the attaching tubes. As a result, local preheating of the fitting may be required in order to obtain a satisfactory weld. This condition can be overcome by machining the forged fitting all over to reduce wall thickness, but it is doubtful if this would cost less than heating during welding, or thin-wall forgings. *(Continued on next page)*

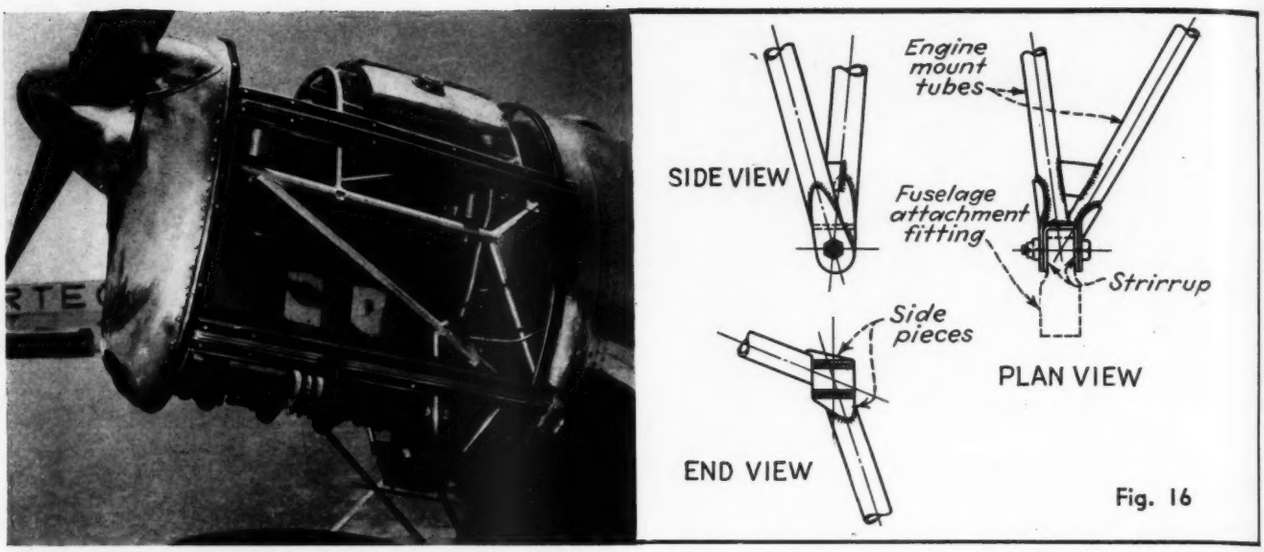
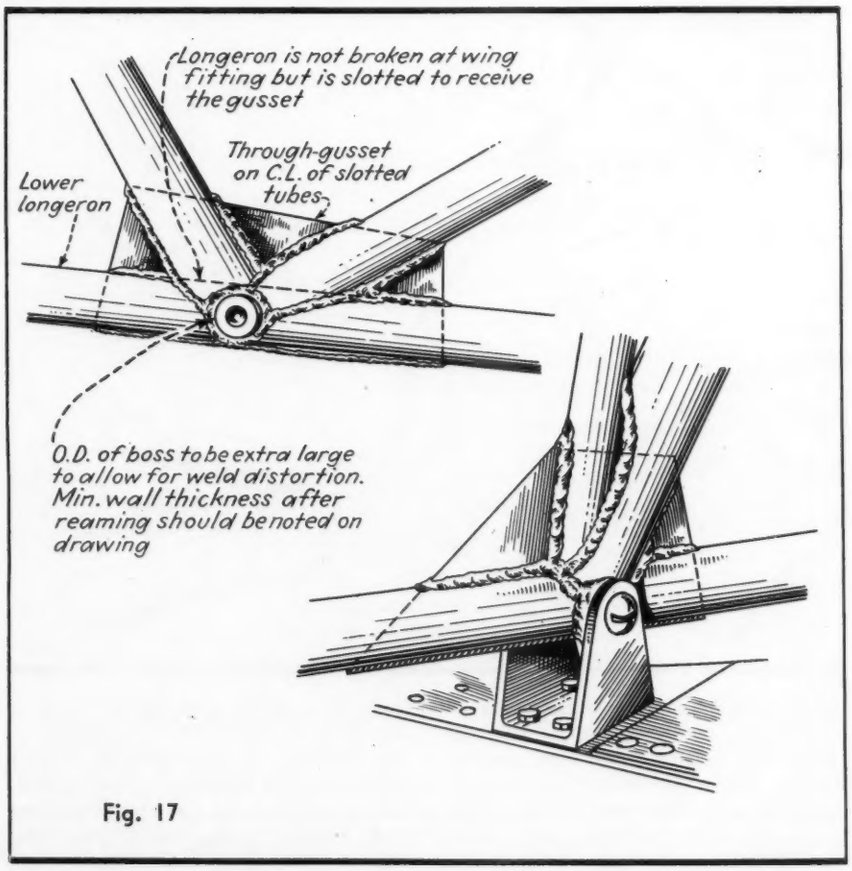


Fig. 16

For small engine mounts, the clevis-type of fitting may be used satisfactorily for connection of mount to fuselage and will be more economical than a forged fitting. The stirrup is formed to a U-section from sheet steel; the side plates can be made on the identical blanking die. The unit fitting, consisting of stirrup and two side plates, is welded as a bench sub-assembly, and later welded to the engine mount tubes. If additional bearing area is required for the attachment bolt, it can be obtained by making the side plates as forgings with heavy bosses for the bolt.

The exact type of tube truss required to support a linear engine will depend upon the cylinder arrangement of the particular engine. This will be realized if it is considered that linear engines are available with cylinders in line or in vee, and may be either upright or inverted. A typical installation for a small inline, inverted engine is shown.

Wing-to-Fuselage Attachment Fittings


Longeron is not broken at wing fitting but is slotted to receive the gusset
Through-gusset on C.L. of slotted tubes
Lower longeron
O.D. of boss to be extra large to allow for weld distortion. Min. wall thickness after reaming should be noted on drawing
Fig. 17

The majority of modern airplanes are of the cantilever, low-wing monoplane type. In most of them the wing attachment method involves connection of the front and rear wing spars to the fuselage lower longerons, thus requiring four attachment points. It is highly desirable that each be made with a single bolt, both to reduce tooling costs and final assembly time. The sketch in Fig. 17 shows a proved method of making provision in the fuselage-lower longeron for the attachment bolt wherein steel bar bosses are welded to both sides of the longeron, with a through gusset providing sufficient weld area for adequate stress transfer. The through-gusset actually passes through the longeron. Side tubes and longeron are slotted on the center line to receive the gusset.

Attachment of wing beam to the longeron fitting is shown at right. This attachment consists of a stirrup type fitting bolted to the wing spar cap strip, and is rather expensive to manufacture, owing to the necessity of accurately slotting a quantity of tubes to form the joint. However, it will permit the transfer of high stresses without danger of failure.

Alternate method of wing attachment shown in left of Fig. 18. The longeron itself is unaltered—neither pierced with

a bolt boss nor slotted for a gusset. This joint will weigh slightly more than the one previously described, but has the advantage of being considerably easier to manufacture. The joint has two straps, one on each side of the longeron, which extend up the side tubes a short distance. The bolt boss is carried by the fitting attached to the wing spar; connection is made by a single bolt. A possible objection to this design over the preceding one is that it weighs a little more, and the attachment bolt is a short distance below the longeron, so that the gap between longeron and wing spar is slightly greater. If the stress being transferred is fairly high, it may be necessary to forge the side straps or machine them from plate stock to obtain thick bosses with adequate bearing area.

Method of wing attachment adaptable to the connection of the lower wing panels of a biplane to the fuselage lower longerons is shown lower right. Fig. 18. This is a variation of the method previously shown, and likewise is readily adapted to production. The side straps may be aligned or straightened after welding, and the attaching bolt hole located, drilled and reamed.

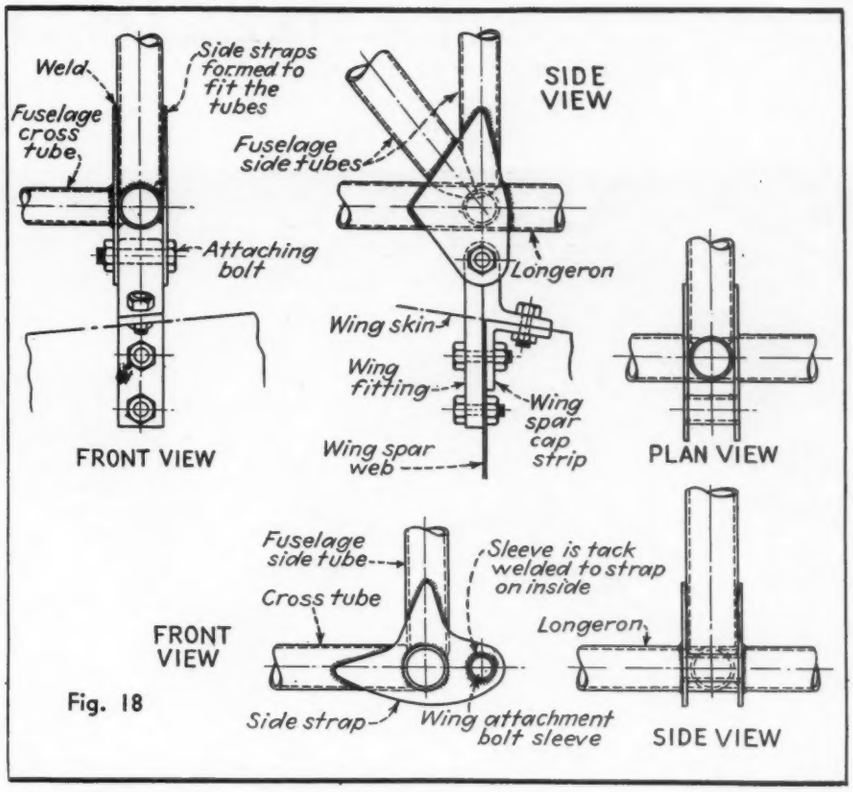


Fig. 18

Overturn Structure for Open Cockpit Planes

Modern open-cockpit airplanes, and others provided with military-type inclosure canopies over the cockpit, are provided with a structure which protects the crew if the airplane should overturn on the ground. This unit is usually a rigid truss structure which rises a sufficient distance above the cockpit to provide the required protection. A typical design, shown in Fig. 19, consists of four heavy-wall tubes of generous dimensions, rising above the upper longerons and joining at a point above the center line of the fuselage. The apex of the tubes is welded and gusseted to a cap sheet of heavy steel plate which provides sufficient bearing area to support the weight of the airplane even in the event of a nose-over on soft ground. On airplanes having military-type inclosures, the crown of the cap plate can be curved to match the inside contour of the cockpit canopy. The design illustrated lends itself well to production, as it is possible to tack-weld all parts into position before the final welding operation is started. Thus only a minimum of set-up time is required. The welding operation can be completed without interruption and without the attendant danger of a partially-welded joint cooling during a secondary set-up before it is finished. (*Part III will appear in December*)

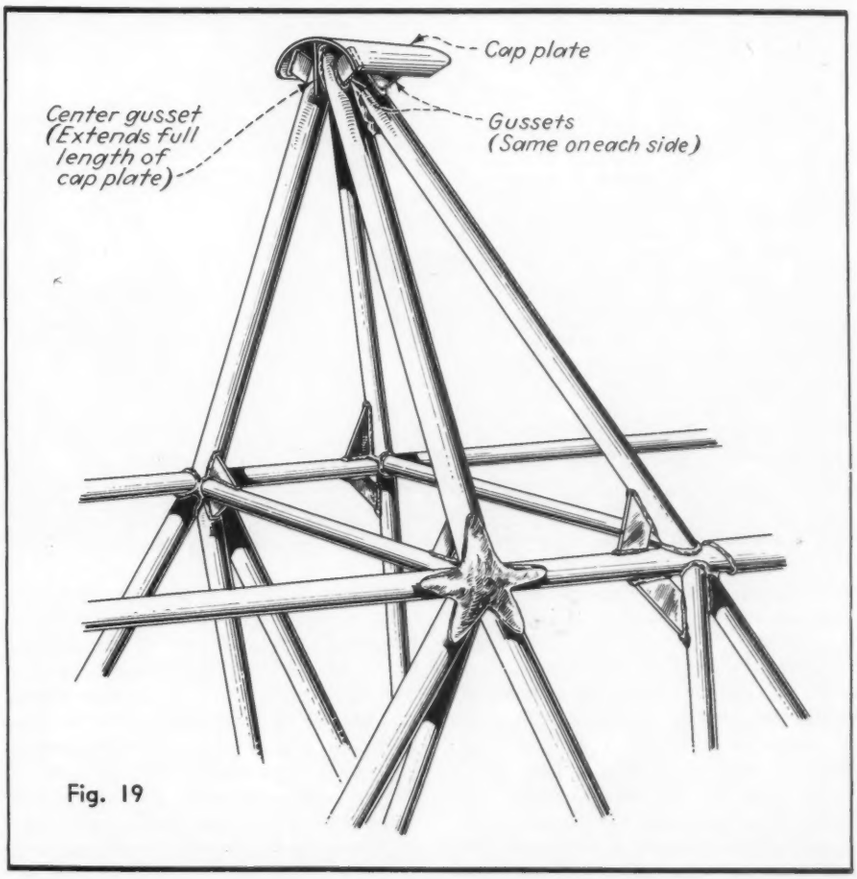
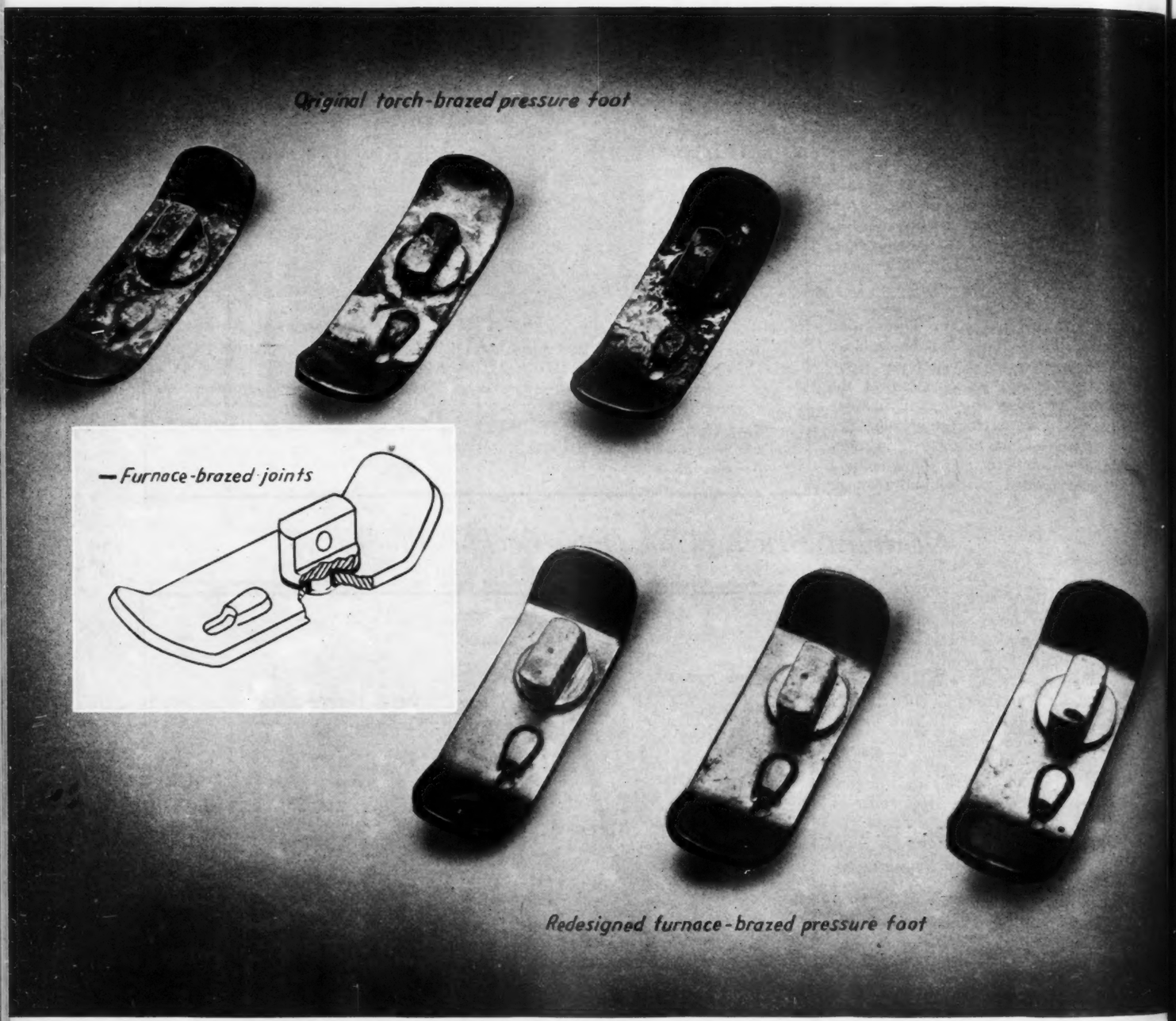


Fig. 19

REDESIGNING FOR UF

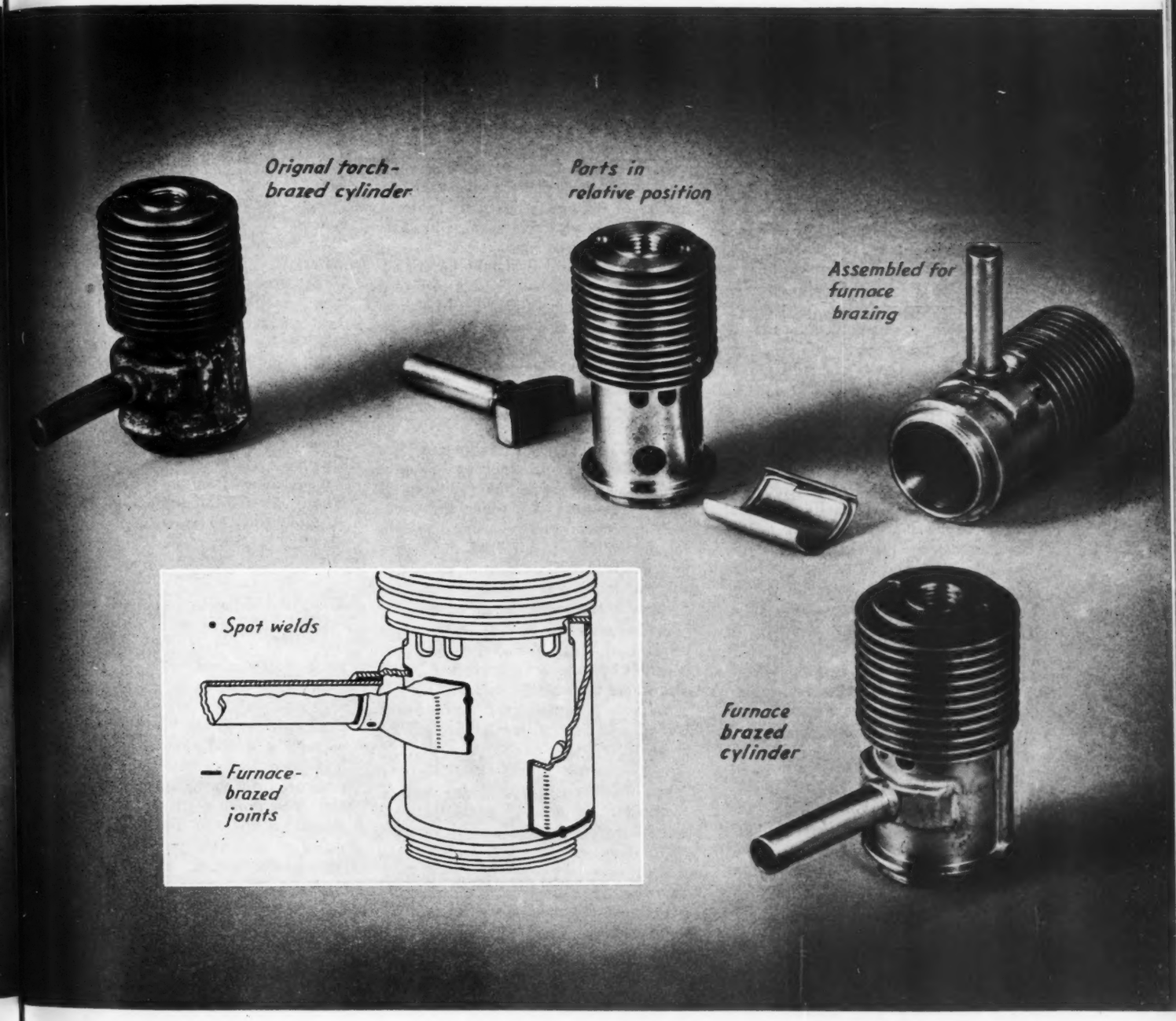
H. M. WEBB[illegible] *Electri*



Pressure foot on high-speed industrial sewing machines, made by Union Special Machine Company, is subject to extreme vibration at high speeds of 6,000 stitches per min., and requires a fabricating method which will give uniformly high strength and long life. When formerly torch brazed with brass spelter and flux the strength was unreliable, rejects were high, and the assemblies had to be pickled to remove oxides and flux. Hand filing was necessary to remove excess brazing metal before the heat-treating operations. Assembly is now made by electric furnace brazing, using the same parts. Copper wire rings are placed at the joints between the parts, and a large number of the assembled parts are loaded on a tray into a box-type controlled-atmosphere furnace. Temperature is automatically regulated and the brazing process is clock-timed by the operator. This gives close control not possible with torch-brazing, and assures that each part will be of uniform high strength. Since the parts are heated and cooled in a protective atmosphere, no flux is required to assure wetting, and no scale forms on the surfaces of the parts. Because of the uniform amount of copper in the wire rings, all assemblies have smooth, neat fillets and no metal need be removed by filing.

FURNACE BRAZING—II

eral Electric Company



Air-cooled cylinders of the Brown Junior model airplane motor, which develops 0.24 hp. at 5,200 r.p.m., were originally torch-brazed at the joints where the exhaust manifold and air-intake manifold are fastened, and where the intake tube joins the manifold. After brazing special cleaning operations were necessary, and rejections because of leakages were many, according to Mr. Edward Roberts, of Junior Motors Corporation. In redesigning for furnace brazing, copper wires are formed into rectangular rings and placed in the two manifolds as shown. The tube is then inserted and spot welded into the intake manifold, and the manifolds are assembled and spot welded to the cylinder to hold assembly together. A ring of copper wire is placed over the intake tube. Assemblies are then set, tube up, in fixtures on a mesh-belt conveyor and passed through an electric brazing furnace. The copper is drawn into the joints by capillary attraction, forming strong, tight bonds and leaving neat fillets which require no pickling, filing or grinding. Non-uniformity has been eliminated, and rejections because of leaks have been reduced. Light weight is essential in the fabrication of this motor cylinder because of its extensive use in airplane and motor boat models.

STUFFING BOXES–II

Pressure Sealing Devices for Rotary Shafts

A. BROTHMAN

Engineering Department, Hendrick Mfg. Company

WHEN deciding whether or not a stuffing box for a rotary shaft need be jacketed, several factors should be considered such as the temperature of the medium surrounding the box, the heat generated by frictional power losses in the box, the heat dissipated from the bearing member, and the heat radiating capacity of the box. The question of cooling the box in order to remove heat imparted to it through contact with a medium may be decided by the general rule that the temperature of the box should not be allowed to exceed 212 to 250 deg. F., especially one containing a bushing or bearing member.

Heat generation and power loss caused by friction can also be evaluated. Let f equal the coefficient of friction of the shaft on the packing and let R equal either the bearing pressure imposed on the packing by the shaft (where the box does not contain a bushing or bearing member) or the reaction of the packing to the shaft caused by the gland pressure, then

$$R = \frac{W - U}{\frac{\pi}{4}(D_2^2 - d^2)}$$

the moment of friction

$$M_f = f R d/2 \qquad (19)$$

and the loss of work by friction in in.-lb. per min. is

$$2\pi M_f N \qquad (20)$$

in which N is the r.p.m. of the shaft. By conversion to appropriate units, the horsepower loss H can be obtained from

$$H = 8\times10^{-5} R f d N \qquad (21)$$

Table II gives, for the various operating temperatures of the box and various conditions of ventilation, the expected radiating capacity of the box in hp. per sq.in. of box surface area. Where the power loss in the box divided by the projected area of the box gives a value exceeding the expected radiating capacity of the box as given in Table II, then the box must be jacketed to effect the proper rate of cooling.

A problem which should be considered in this connection is that of forced lubrication of the stuffing box. Lubrication is adopted as a means of increasing the life of the packing and/or decreasing the frictional power loss when the gland pressure is high.

Forced lubrication of the box becomes necessary when:

1. The packing used does not contain, by impregnation or otherwise, its own lubrication; or when the condition of gland pressure under which the packing's lubricant is yielded is one at which, for the shaft speed involved, the nature and quantity of lubricant available in the packing is not sufficient to reduce materially the coefficient of friction.

2. The bearing reaction of the shaft on the bushing and/or on the packing is constant in direction and eccentric, and also where the speed of the shaft is such as to cause a gathering of the lubricant behind the line of maximum bearing pressure.

3. The rotary shaft is subject to "chattering" or vibration, or the shaft is operated at or near its critical speed, thus increasing the tendency to rupture the lubricant film. Whether forced lubrication is necessary or not may be judged from the use of an empirical equation, in which R is either the radial squeeze of packing or the load imposed on the packing by the shaft, A_2 is the area of shaft in contact with the packing, and v is the surface speed of the shaft in ft. per min.

$$\left(\frac{R}{A_2}\right) v = 150{,}000 \qquad (22)$$

When, for any given condition, the calculated quotient exceeds 150,000, then forced lubrication becomes mandatory.

The decision to jacket the box should also be influenced by the quantity of heat generated in the bearing or bushing during service. Equations (19), (20) and (21) can be applied to calculate the heat generated through friction where R is taken as the load imposed on the bushing by the shaft. The radiating capacity of the box as it affects the dissipation of heat from the bushing can be determined from the use of Table II. The required heat dissipation capacity is determined by the ratio.

$$\frac{Hp_B}{\pi D_B l}$$

When the value so calculated exceeds the radiating capacity of the box as indicated in Table II, then jacketing of the box is required.

In the design of rotary spring pressure type seals the important considerations are: the spring load, the selection of rider and seal ring assembly members, and the provision of adequate lubrication for the seal and rider assembly. The problem of the selection of proper materials for the seal rider and seal ring assembly is concerned with two factors: first, the condition of corrosion which is encountered and, second, the estimated bearing pressure established in the assembly. The question of the corrodibility of the materials in the seal ring rider should be considered from the standpoint of the corrodibility of each material separately, as well as from the possibility of reduced corrosion resistance of either material in the presence of the other, that is, the possibility of a galvanic couple being set up with the medium against which the seal works should be investigated.

Referring to Fig. 2 (Part I, page 417, PRODUCT ENGINEERING, Sept., 1940), it will be seen that in order to calculate the spring load it is necessary not only to calculate the force required to deform the neoprene washer, but also to

Table II—Heat Dissipation in Boxes

Temperature Rise in Box, Deg. F.	60	90	120	150	180	
Well Ventilated Box	0.061	0.16	0.21	0.44		Heat Dissipation in terms of HP. per sq. in. of radiating surface
Warm Atmosphere Contacting Box	0.033	0.066	0.11	0.18	0.25	
Box Integral with Device Functioning at Elevated Temp.	0.012	0.019	0.024	0.032	0.044	

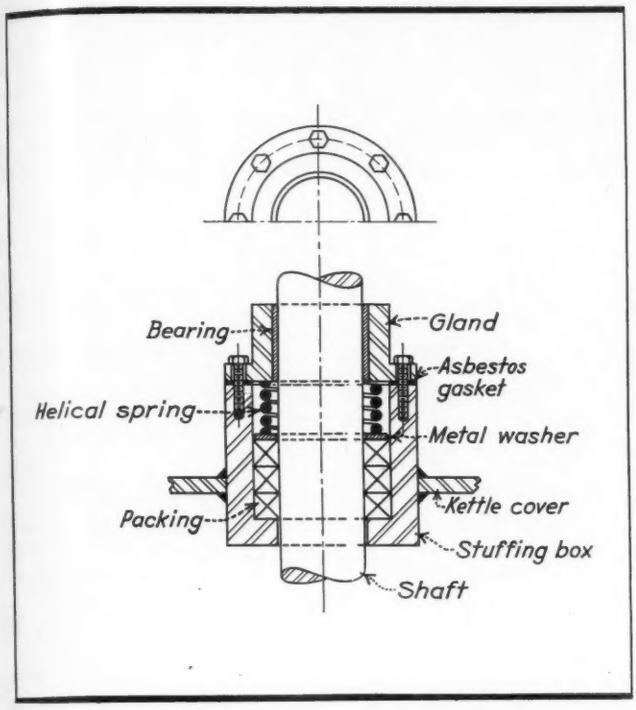


Fig. 7—Box with a spring compensating seal. Bushing in gland prevents whipping of shaft thus increasing packing life

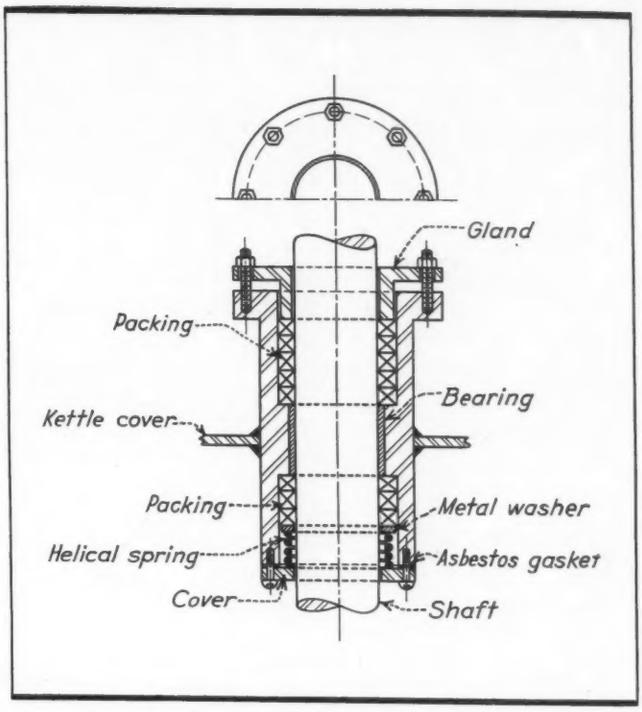


Fig. 8—Internal and external boxes combined in one unit to obtain tandem action, prevents leakage from external box

calculate the contact load for the seal ring. Let F_4 equal the force to deform or yield the neoprene washer, then

$$F_4 = \pi\, b\, C\, y \qquad (23)$$

Also let F_4 equal the minimum force required to compress the washer under operating pressure to obtain a tight joint, then

$$F_4 = 2\pi\, b\, m\, p\, C \qquad (24)$$

Let U equal the hydrostatic end force acting on the seal assembly, then

$$U = \frac{\pi}{4}\,(C^2 - d^2)\,p \qquad (25)$$

The seal ring yielding load F_6 is

$$F_6 = \pi\, b\, C\, y \qquad (26)$$

The seal ring yielding load under pressure F_7 is

$$F_7 = 2\pi\, b\, m\, p\, C \qquad (27)$$

The largest of the sums

$$\begin{matrix}(F_4 + F_6)\\ (F_4 + F_7 + U)\\ (F_5 + F_7 + U)\\ (F_5 + F_6 + U)\end{matrix} \qquad (28)$$

can be taken as the spring load. The diameter of helical spring coil d_s to effect the imposed load W can be obtained from

S_s = allowable unit stress in spring coil, lb. per sq. in.

(The allowable unit stress in spring coils may be taken at 60,000 lb. per sq. in. for steel springs in high-pressure rotary spring pressure seals, at 60,000 to 70,000 lb. per sq.in. for heavy-duty service steel springs, and up to 110,000 lb. per sq.in. for light service steel springs, this latter value should not be exceeded, even in low pressure seals.)

$$W = \frac{\pi\, d_s^3\, S_s}{8\, C} \qquad (29)$$

while the number of coils n to be used can be determined from

G = torsional modulus of material in spring

f_s = allowable deflection in helical spring coil

$$n = \frac{G\, d_s^4\, f_s}{8\, W\, C^3} \qquad (30)$$

The thrust load imposed on the shaft as a result of the spring assembly is W. And similarly the thrust load assumed by the seal ring rider assembly is W minus U. Therefore, the seal ring may be proportioned by choosing values for

d_1 = outside dia. of thrust loading seal ring

d_2 = inside dia. of thrust loading seal ring to satisfy the equation

$$P = \frac{W - U}{\frac{\pi}{4}\,(d_1^2 - d_2^2)} \qquad (31)$$

In applying Equation (30), the safety factor should be liberal for the allowable bearing pressure when the peripheral speed of the seal rider exceeds 600 ft. per min. in order to take care of poor lubrication that may result from centrifugal force acting on the lubricant between the seal rider and seal ring. For normal lubrication, the allowable bearing pressure P can be obtained for any mean surface speed in ft. per min. of seal rider v_1 from the equation

$$Pv_1 = 100{,}000 \qquad (32)$$

Since the moment of friction for the thrust loading seal ring is

$$\left(\frac{f}{3}\right)(W - U)\left(\frac{d_1^3 - d_2^3}{d_1^2 - d_2^2}\right) \qquad (33)$$

then the friction loss of power will equal

$$1.7 \times 10^{-6}\,\pi\, f\,(W - U)\left(\frac{d_1^3 - d_2^3}{d_1^2 - d_2^2}\right) \qquad (34)$$

Knowing this, it is possible to make provisions for jacketing the box in accordance with the laws previously set up.

Because of the great variety of possible designs which employ a rotary spring pressure seal, some of which are shown in Figs. 7, 8, 9 and 10, both in the seal assembly (double or single seal assemblies) and in the containing box, basic equations for dimensioning the box cannot be set up, however, the rules set down with regard to rotary spring pressure design can in their form be manipulated to accommodate any variation in the design of the assembly.

The type of box having a spring compensating seal, shown in Fig. 7, can be used in applications where a bushing in the floor of box would not be desirable because of the presence of corrosive material in the tank to which the box is

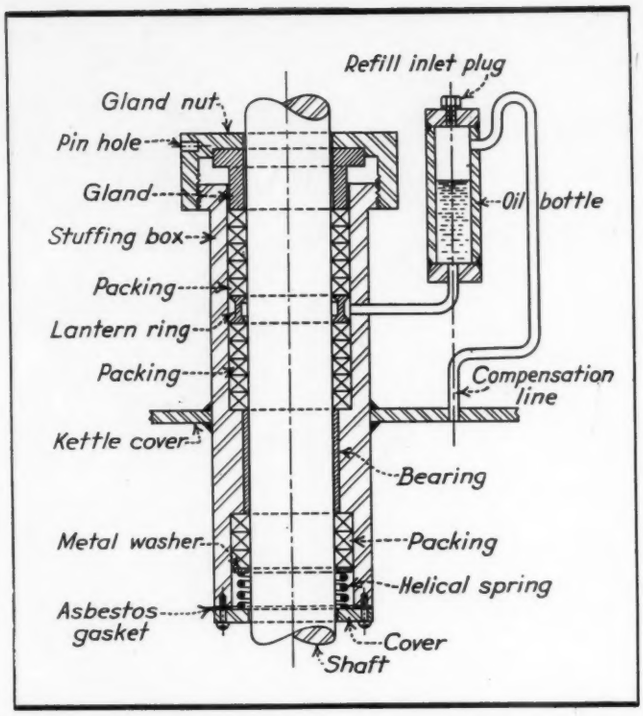


Fig. 9—Forced lubrication of box to reduce friction is obtained by head on oil equal to the internal pressure in kettle

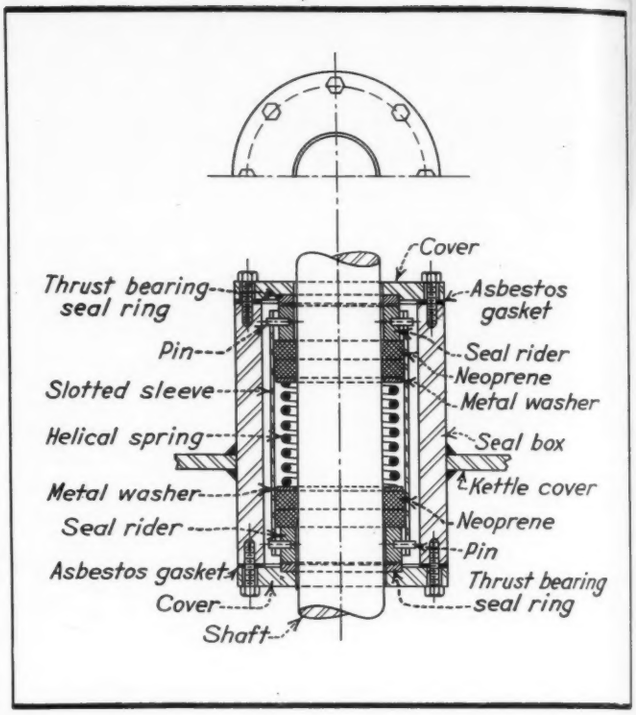


Fig. 10—Rotary spring pressure seal in which a spring forces two sets of neoprene rings to seize shaft and also sleeve tube

attached, or where lubricant leakage from a bushing in the floor would be injurious to material in the tank. The gland bushing prevents deflection or whipping of the shaft thus increasing the life of the packing.

Another design of box shown in Fig. 8 in addition to the conventional box includes a spring compensating seal. The design advantages of this type are tandem action of an internal and an external box, and prevention of lubricant leakage from external box into the kettle.

The type of box shown in Fig. 9 differs from the one shown in Fig. 8 in that forced lubrication is provided to reduce the coefficient of friction between the shaft and the packing. With an increase of the internal pressure in the kettle the pressure on the lubricating oil also increases.

The rotary spring pressure seal shown in Fig. 10 has been used successfully on kettles in vacuum, low and medium pressure ranges with high speed shafts. In this design a helical spring deforms two sets of neoprene rings, forcing these to seize the slotted sleeve and also the shaft, leakage along the shaft is thus prevented, also the seal rider is forced to rotate at a fixed pressure against a thrust loading seal ring which prevents or throttles down leakage at the point of entrance of the shaft into the box.

A comparison of the merits of the types of seals discussed may have some value. Since the rotary spring pressure seal is less known and more recent in development than the typical packed box, it is well to approach this subject from the standpoint of the advantages of the former over the latter. Briefly put, these may be listed as:

1. Reduced frictional loss of power especially when sealing against high pressures
2. Absolute protection against "scoring" of the shaft as frequently occurs with packed boxes
3. With proper design the life of the seal as an efficient device is much longer
4. Makes possible the incorporation into the box of anti-friction bearings thus insuring reduced whipping of the shaft when the bearing loads are heavy and lower maintenance on the mechanism as a whole.

For most applications, the advantage of the packed box as opposed to the rotary spring type is the cheapness of original fabrication. Furthermore, in certain installations where the medium against which the rotary seal works is corrosive to all of the ring-seal rider assemblies available, a box packed with a chemically inert packing may provide the only answer.

It is important to note that in any comparison of these basic designs one should not lose sight of the fact that these two types of seals are capable of complementing one another. There frequently arises the problem of sealing lubricants contained in the packed box against possible leakage into the mechanism to which the box is attached. To meet this difficulty internally and externally packed boxes are sometimes used, however, such designs usually involve difficult adjustment of the packing in the internal box and frequently injudicious tightening up on the packing with attendant difficulties.

Current Quotations

"Scientists speak casually of harnessing the winds for power, of drawing upon the heat of the sun, of using even the surge of the tides for power to replace fuel that by then may be gone. Laws will not prevent men from thinking. And so long as they think, so long as they refuse to accept the present age as perfect, advances will be made."—

DR. EDWARD R. WEIDLEIN
Director, Mellon Institute of Industrial Research

News and Summaries

National Defense Progress Not So Slow As It Seems, Washington Sources State

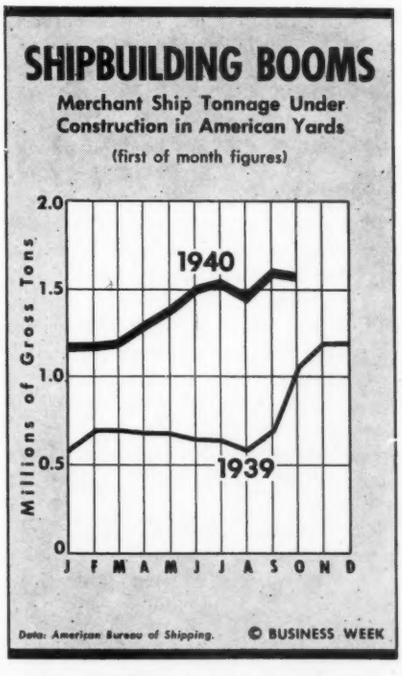
Army, Navy and national defense officials say defense preparations are "running smoothly" and express complete confidence in existing designs

TOP-RANKING business executives of the nation believe that national defense preparations are not as effective as they might be, according to the *Fortune* Forum of Executive Opinion. Undoubtedly this seems to be the national "beef", but it is unfounded, according to Washington sources. Military, naval and defense men have told PRODUCT ENGINEERING that defense preparations are running "as smoothly as can be expected."

A review of reports made during the past few months substantiates this. True, there have been and still are difficulties, but the whole picture is encouraging. Take the spotlighted aircraft industry as an example. Major units (Martin, Boeing, Douglas, Curtiss-Wright, Pratt & Whitney, Packard) are already pushing expansion to the limit. Martin alone is spending $24,000,000 of their private funds, Packard is spending $30,000,000. Total production capacity has already been upped from 6,000 to nearly 10,000 per year. Although slightly behind schedule now, it is expected that by the end of the year the rate will be 13,000. In 1941 it will reach 24,000 and 1942 will see 35,000 planes turned out. Boeing now completes Army trainers at the rate of one every three hours, a figure which will be increased to one every 90 min. in four months. Training planes are to be delivered to our government first, so that when fighters are delivered in large quantities there will be pilots to fly them. Roughly 40 per cent of our production during the next year will be pursuit planes sent to Britain to keep the Messerschmitts out of London's hair. Ford's new aircraft engine plant will be turning out Pratt & Whitney air-cooled engines at the rate of 15 per day within eight months.

We read in the newspapers that it will take 5 years to get a two-ocean Navy, and read of new and reconditioned yards just beginning to lay keels for new ships. But it is not generally realized that some of the ships included in the plans have already been delivered, and others have already been launched or will be launched in the near future. It is not as discouraging as if we weren't to have any ships at all for five years. Then too, speed-up in shipyards can and will greatly reduce that 5-year figure.

On the all-important arms and ammunition industry, little has been reported. It is known that arsenals are on a three-shift basis, though they are having trouble securing enough skilled men. For ordnance purposes almost 100 plants are planned. Over 60 per cent of the money made available by Congress for munitions manufacture has already been awarded. Garand rifles are said to have reached a production of 500 per day at one arsenal alone. About tanks, it is known that light tank production is now 100 units per month, and is rapidly increasing.



Maritime Commission is pushing merchant shipbuilding so that the country can be ready for any shipping emergency. The boom is already a year old. On Oct. 1, 329 vessels were on the ways

The machine tool industry is pointed to as one of the most critical bottlenecks. Machine tool builders suddenly found themselves with a four-fold increase in business, and with a tough problem as to who needs the machines most. But they jumped quickly and voluntarily into a close cooperation with the Defense Committee. Knudsen recently stated that the builders are looking for subcontractors of parts, have found some, and are thus greatly increasing their capacity.

Materials are not giving much trouble. Away back in July the steel industry took stock and reported that the only serious bottleneck might be in armor plate production, this in spite of the fact that one maker boasted he could make all the light plate required. Few companies have had experience in fabricating armor plate. There might be a squeeze on alloy steels, but this can be corrected by using plain steels in certain non-essential applications. Blast furnace, open-hearth, and bessemer furnace capacities are sufficient. Strip and sheet mill facilities and tube mills are adequate. Electric furnace alloy steels are now on the short end of capacity, but expanding. Strategic materials are little cause for worry, Washington states, as long as we are careful with them.

Reassuring reports have also come from such widely diversified industries as textiles (which industry states that mistakes of the last war are being averted this time), railroads and transportation, foods, rubber and petroleum.

Static Period Almost Over

One reason set forth for the prevalent feeling regarding the effectiveness of our national defense is that many people do not fully understand the "static" period that must precede large scale production. Product engineers do understand this phase, because in it design is an important element. In addition to settling on designs, much time must be consumed in determining production needs, financing expansion, clearing orders, training personnel, and in this case providing new laws to take some of the load and risk of expansion off the shoulders of defense manufac-

turers. Most of this work is now done.

What seems to be intelligent criticism shows an understanding of the static period, gives designers and manufacturers a clean slate, but claims that much of the political "hogwash" attendant to defense provisions could and should be eliminated. Predictions are that after the election politicians, military men and industry will get together.

New Glass Treatment Increases Transparency

GLASS SURFACES can be made more transparent by a new surface treatment, it was recently reported to members of the Optical Society of America. Research now being conducted by Frank L. Jones and Howard J. Homer at Mellon Institute indicates that by dissolving away the oxides from a thin layer on the surface of the glass the polished surface reflects less and transmits more light. Previous methods achieved the same effect by applying molecular films of another material.

If the solvent used does not dissolve silica, no damage is done to the surface polish. A weak acid solution, such as one per cent nitric acid, was found to be the best solvent, although solutions of salts, alkaline phosphates, melted salts and even water were found to show the effect in varying degrees. Glass surfaces not freshly prepared were found to react in an uneven fashion. However, once the surface film has been formed it can be processed in various ways that will render the surface unreactive, so that a second treatment will not appreciably change the thickness of the film.

This new process may have widespread use in all types of optical instruments, such as photographic lenses which may be made "faster," astronomical telescopes, periscopes, and telescopes for night use.

Resistance Welding Welds Heavy Sections

FORGE-WELDING, a new process of heavy-duty electric resistance welding, makes possible the spot welding of heavy steel and iron sections heretofore considered impossible to weld with conventional equipment. Typical of work which can be handled is welding of two pieces of 3/8-in. stock to a 1-in. section.

Resistance forge-welding, according to Progressive Welder Company, consists of first applying pressure to the work, then interrupted current, and finally super-imposing a hammering action on the electrode. Under high pressure and with sufficient heat, the surfaces of work are brought into such intimate contact that when additional "impact-pressure" and intermittent heat are applied a forged weld of superior quality is obtained.

Ideal conditions have been provided for All-Steel Equip Company design engineers. Fluorescent lights spaced 5 ft. apart in ceiling troughs provide a maximum light reading of 61 ft.-candles. Use of fluorescent lighting made it possible to use 23 tons less refrigeration in the entire office. Air conditioning system provides six complete air changes per hour. All heat and air conditioning ducts are concealed above the ceiling where Anemostats and grilles for exhausting used air are installed flush with the acoustic tile. Of particular interest are the arrangements for the comfort of draftsmen. Drawing tables are kept clear by providing desks which the draftsman can reach by turning his posture chair. Desks are higher than standard size to permit this.

Passivation of Steel Not an Inherent Property

PROTECTIVE FILMS on iron and iron alloys are effective only under certain conditions and in certain environments, stated G. C. Kiefer, of Allegheny Ludlum Steel Corporation at the 22nd annual convention of the American Society for Metals in Cleveland, in a paper entitled "The Passivation and Coloring of Stainless Steel."

The corrosion resistance of metals other than the noble metals is probably due to causes apart from their atomic structure. Under one set of conditions alloys of iron may show considerable resistance to corrosion, while under another set of conditions they are probably attacked. Hence it becomes apparent that a change in surface condition of the metal or alloy must be responsible for its corrosion resistance.

Some metals, such as aluminum and chromium, have a much stronger tendency than others to form protective films. Some, but not much, evidence has been advanced on the nature of these films. Passivation is usually attributed to the forming of an insoluble oxide or hydrate film. It has been found that the influence of a protective film on alloys of chromium and iron is more marked than with any other metal or alloy. The addition of molybdenum to chromium and chromium-nickel alloy is particularly effective in increasing passivity because it strengthens and stabilizes the protective film in non-oxidizing acids and environments where partial destruction of the film is apt to occur. Mr. Kiefer also gave a brief general discussion of the art of coloring stainless steels.

Do You Know That—

PLASTICS for injection molding can now be colored with fluorescent dyes which glow under certain light conditions. Cost is no higher. (30)

DIESEL ENGINE has advantage over gasoline engine for Army tanks in that no radio shielding is required, since there is no electrical ignition system. One tank out of three is to be equipped with two-way radio. (31)

MAGNESIUM ALLOY manufacture and fabrication, contrary to recent Department of Justice assertions, are not controlled by German patent interests. A magnesium patent holding company owned jointly by German and American firms controls the patents of both countries and has eliminated the necessity for either country paying royalties to the other for the use of her patents. (32)

ENGINEERING IN WASHINGTON

McGRAW-HILL WASHINGTON BUREAU, *PAUL WOOTON, CHIEF*

Re-styling and redesign of non-defense products will become steadily less frequent. Defense Commissioner Knudsen says he plans to use the entire tool output for setting up defense plants. This means that any product which is in mass production to the extent of using single-purpose tools is going to have a mighty hard time re-tooling for any extensive changes. It is now practically an accepted fact that changes in 1942 automobiles will be restricted to the barest minimum. Shortages of materials, resulting from defense production, may however, set up a trend in the opposite direction. No real shortages yet exist, but when and if they show up a lot of products will have to be modified to permit use of substitutes.

Camouflage paint is rough, and it constitutes a serious impediment to the free flow of air on plane surfaces. But the concealment it offers offsets the disadvantage in speed, in the opinion of tacticians. Mottled green and brown is the best combination for top camouflage to blend with all types of ground. Bottom surfaces are not so easy. Various shades of gray and blue are best for daylight, but the color of the sky varies widely. It has been found that a solid coating of lamp black offers best concealment at night, because it reflects the least light from search beams. A Flying Fortress recently passed through a beam of 800,000,000 c.p. undetected.

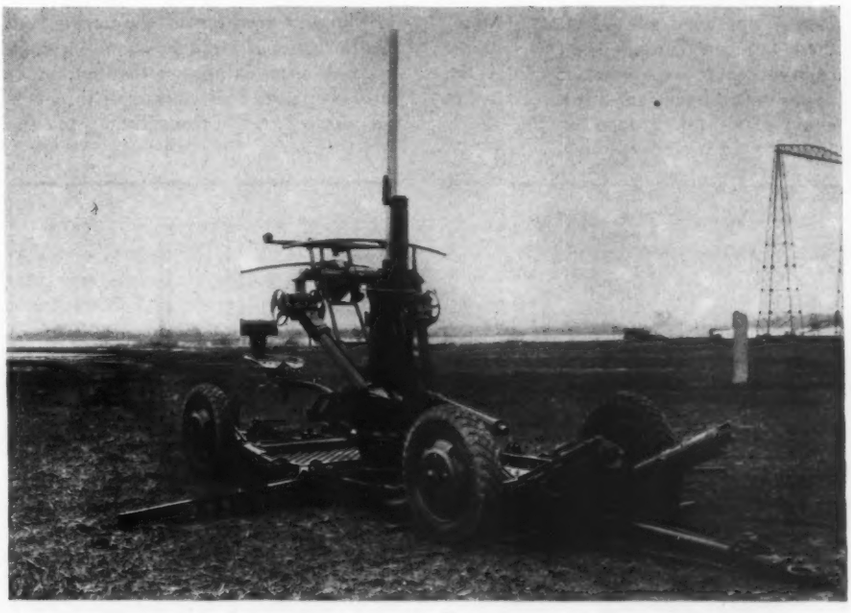
Welding of Army tanks is going to be news soon. Experiments made in connection with design of the new 25-ton tanks showed that rivets are a hazard. When a bullets hits the outer head of a rivet, the inner head flies off and may kill or wound a man. Welding presents difficulties because it spoils heat-treatment of armor plate at seams. How they overcome this will make quite a story.

Fast heat-treatment furnace for formed aluminum parts, developed by Northrop Aircraft is aiding the air defense program in two ways. Aluminum, like other metals, is subject to corrosion —a serious thing in vital airplane parts. Research shows that susceptibility to corrosion is reduced if the time between oven and quenching tank is reduced. Northrop has reduced this time from 8 sec. to 2½ sec. by designing special furnaces. The second advantage gained is, of course, the saving of time itself.

Powered gun turrets on fighting planes are the newest advance in American design. The new Martin PBM long range patrol bombers, now being delivered to Navy, have powered gun mounts that are claimed to be superior to the English type which has been very successful in the British Boulton-Paul Defiant. Because it is believed more development work may be necessary on American designs, the government has imported already proven British powered gun turrets which will be placed into immediate production.

Standardization of airplanes means several different things. It can mean standardization of types by picking one model for each tactical mission and having the whole industry grind it out. Or it can mean interchangeability of parts and sub-assemblies between different models. Some thought was given to the first kind a few months ago, but it was decided that immediate production would be slowed if one company were told to build the models of another company. Standardization of types will, however, be initiated in 1942 when the planes now being ordered have been delivered and the plants are tooling up for new models. Interchangeability of parts is in the hands of the Army-Navy Aeronautical Board.

Glass-insulated diving suits have increased the Navy's maximum practical working depth from about 260 to 340 feet, and to 400 feet open ocean diving. It has been known for some time that a mixture of helium and oxygen would permit deeper diving. But helium conducts heat away from the body rapidly, causing the diver to suffer intense cold. If electrically-heated clothing were used to counteract the cold, there would be danger of a short-circuit igniting the mixture of oxygen and insulating fiber. The answer was spun glass insulation.



Army's latest 37 mm. anti-aircraft gun fires 125 shells per min., is aircooled, and travels on rubber-tired trailer unit. Shells have muzzle velocity of 2,600 ft. per sec., vertical range of 6,500 yd., 9,300 yd. horizontal range.

Question and Comment

Location of Jam Nuts

J. J. PESQUEIRA

THE FUNCTION of a jam nut is that of preventing the main nut from rotating on the screw and eventually loosening. Principles underlying the proper location of the jam nut are very simple and understandable to anyone. In spite of this, the number of improperly located jam nuts found in assemblies is surprisingly large. Hence, the designer must definitely specify proper location on his assembly drawings.

In no case should the jam nut be thought of as aiding the main nut in carrying the load on the screw. Incorrect location of the jam nut means that this nut will carry the entire load. If, as is current practice, the jam nut is thinner than a standard nut, the jam nut thread will yield under excessive stresses, the load will be transferred to the main nut, and the locking relationship will be destroyed.

How the jam nut locks the main nut is shown in Fig. 1, where the clearance between the screw thread and the thread of the nuts has been exaggerated for clarity. When the two nuts are sufficiently tightened one against the other, their adjacent ends will react against each other in compression, while the upper face of the jam nut thread bears against the lower face of the screw thread, and the lower face of the main nut thread bears on the upper face of the screw thread. Main and jam nuts that have not been sufficiently tightened against each other will not lock properly and the jam nut would be useless.

When the main and jam nuts are brought to proper locking relationship, as described above, either one or the other will carry the entire load on the screw. Which one will do so depends on the location of the two nuts. The following typical examples demonstrate the proper relative location of the nuts.

Fig. 2 shows the assembly of the two halves of a connecting rod head by two bolts the size of which have been determined to take care of the tensile load on the connecting rod. The nuts on the right-hand side bolt are properly located, whereas those on the other bolt are not. Assuming that the two nuts of each pair have been sufficiently tightened, only the upper nuts are carrying the load. Referring again to Fig. 1, where the main and jam nuts are purposely shown in wrong relationship, it will be perceived that to the tensile load on the screw there corresponds a compressive load acting on the bottom of the lower nut. This compressive load is not immediately transmitted to the screw, but is passed on to the upper nut, from which it will now be transferred to the screw to close the force circuit. It is doubtful that, under the screw load, there could be sufficient elastic yielding of the various interacting elements for the lower nut thread ever to bear fully on the lower side of the screw thread. In this and similar applications, the place of the jam nut should be under the main nut, as in this position its thread will be free from the load.

The application shown in Fig. 3 embodies the commonly employed screw

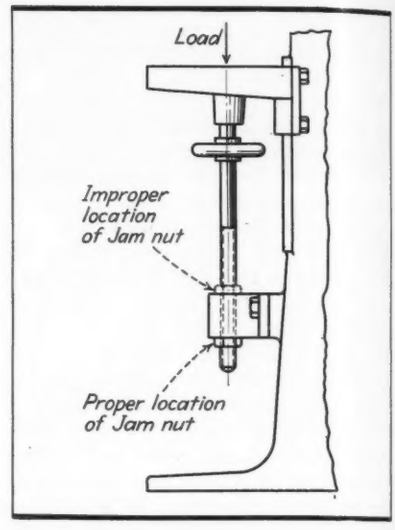


Fig. 3—Jam nut location on table screw

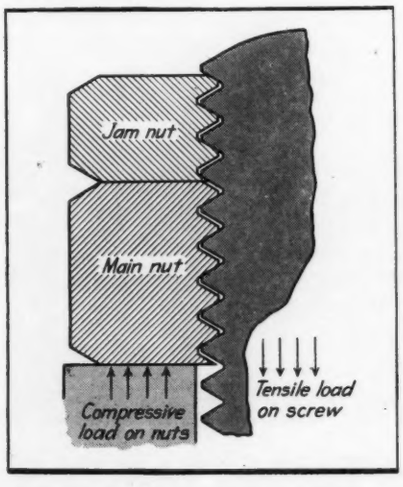


Fig. 1—Principle of jam nut locking. Jam nut is incorrectly placed here

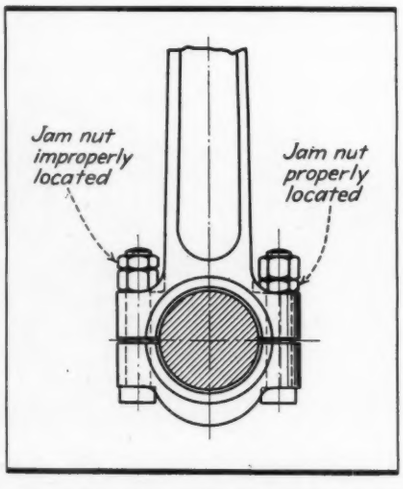


Fig. 2—Properly and improperly located jam nuts on connecting rod head

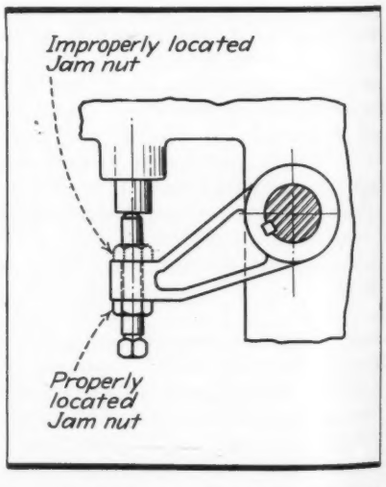


Fig. 4—Proper location of jam nut on an adjusting screw

for raising and lowering the working table of a small machine, such as that of a light nailing or riveting machine. The screw engages a threaded hole in a stationary bracket below the table. To lock the screw, a jam nut is often used. It often happens that the thin jam nut is thoughtlessly placed on the top of the bracket, as shown in the figure. When the nut is tightened the table screw is slightly lifted, so that the screw thread will bear on the underside of the bracket thread. Under these conditions it will not be possible for the bracket thread to carry the screw load, and the burden will be shifted to the jam nut. If the jam nut is placed at the bottom of the bracket, as shown in dotted outline in the figure, the screw thread will bear on the upper side of the bracket thread, and will carry the screw load. In this particular application the jam nut at the bottom of the bracket admittedly has the disadvantage of being less accessible than at the top.

In the example of Fig. 4 the jam nut locking the adjusting screw, which receives a compressive load, is properly located at the bottom. The reason for this is the same as that in the case of Fig. 3. The adjusting screws of operating levers like this are usually subjected to severe impact loads, and it is here that special care should be exercised.

[*Editor's Note*—This is a subject which has long been in controversy between mechanical engineers. We don't claim Mr. Pesqueira is right, and we don't allow he's wrong. Let's get this settled once and for all. What do you think?]

Horse of a Different Color

To the Editor:

On page 379 of your August number (New Materials and Part Section) you have an item relative to the new Type D Mu-Switch and state that the molded plastic housing of this switch withstands temperatures up to 900 deg. F. I wonder if this is an error or if it is possible that some new type of organic hot molded plastic has been developed which will withstand temperatures higher than 475 deg. F.—DON MASSON
Bakelite Corporation

To the Editor:

In reply to your recent letter, the compound used in the construction of the Type D Mu-Switch housing is the General Electric 94-D compound which is a cold molded material. Heat treating after molding renders this housing capable of withstanding temperatures up to 900 F. —C. W. METCALF
Mu-Switch Corporation

Wine Dilution Problem Right or Wrong?

To the Editor:

Referring to Mr. H. E. Smith's solution to his July "Wine Dilution" problem in the August PRODUCT ENGINEERING, page 376, we question his results and should be very glad to hear if any other solver has gotten his answer. In the last paragraph he says that there are 12½ drops of 0.001 gal. each per day, but the truth is there are 125 one-thousandths of the gallon in one pint and not 12½ as he says.

—CARL P. NACHOD
Nachod & U. S. Signal Co.

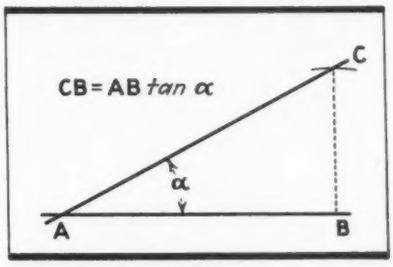
[*Editor's Note*—The problem was wrong and Mr. Nachod is absolutely correct, Mr. H. E. Smith hastens to admit. The correct answer works out to 36.57 per cent wine remaining in the jar. In admitting this slip, Mr. Smith made some emphatic remark about decimal points. We didn't quite catch what he said, but we think we know what he meant.]

Offer Simpler Methods For Determining Angles

To the Editor:

After looking over Mr. Drachman's short article "Trigonometric Method to Determine Angles" (PRODUCT ENGINEERING for August, page 375), I recall a simpler method that was taught me some fifteen or sixteen years ago, when I was a struggling young draftsman.

For example, if an angle of 27 deg. 49 min. is to be laid out as shown in the diagram, choose a base line of any convenient length *AB*, 5 in. in this case. Referring to a table of tangents, the tangent for 27 deg. 49 min. is 0.52761. Multiplying this tangent by 5, we get the figure 2.638. Then constructing perpendicular *BC* 2.638 in. high, draw line



AC which will produce an accurate angle of 27 deg. 49 min. This method can be made considerably more accurate by taking line *AB* of greater length, such as 10 in., although the method begins to get clumsy as an angle of 45 deg. is approached.

—RALPH H. WELLER
Booth Brothers Company

To the Editor:

Mr. M. K. Drachman in his "Trigonometric Method to Determine Angles" wished to know if any information concerning his method or formula had been found elsewhere. Although I have never seen his particular method for

Can You Work This One?

H. E. SMITH

Solution to September problem—

How Deep the Pond?

A man, wanting to know the depth of his pond, noticed that a water lily growing straight up from the bottom had its blossom 1 ft. above the surface. This blossom was blown over by a strong wind until it rested on the surface, at which time it was 6 ft. from its original position (not on the surface). By diagram, where R is the stem length,

$$X^2 + 1 = 36, \text{ hence } X^2 = 35$$
$$R^2 = 35 = (R-1)^2$$

Solving this equation, $(R - 1) = 17$ ft.

This month's problem—

Author! Author!

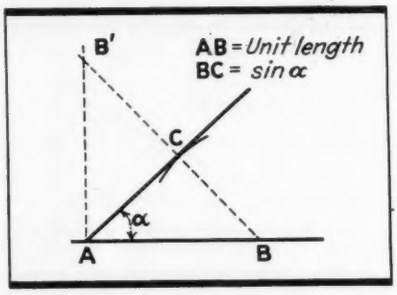
Six authors are seated, three on a side, in a first-class railway compartment. Their names are: Black, Brown, Gray, Green, White and McGillicuddy. They are (but not respectively) an essayist, a historian, a humorist, a novelist, a playwright, and a poet. Each is reading a book which some other occupant of the compartment has written.

Mr. Black is reading essays. Mr. Gray is reading a book by the author sitting opposite him. Mr. Brown is sitting between the essayist and the humorist. Mr. McGillicuddy is sitting next to the playwright. The essayist is facing the historian. Mr. Green is reading plays. Mr. Brown and the novelist were at school together. Mr. Black, who is in a corner seat, has no interest in history. Mr. Green is facing the novelist. Mr. McGillicuddy is reading a book by the humorist, and Mr. White never reads poetry. Classify each of the six authors and tell what they are reading.

constructing angles used before, the formula $L = 2R \sin 1/2\alpha$ is commonly used for determining the length of a chord.

However, I might suggest that as long as he must make two measurements (L and R) in his construction, the following method is just as simple and saves hazardous multiplication.

Along the base line from point A in



the diagram herewith, lay off one unit, preferably 1 in. From this point B swing an arc equal in radius to the sine of the angle to be constructed. Draw AC tangent to this arc and you have CAB, the angle desired. To avoid any construction difficulties for angles approaching 90 deg., use a unit length AB' on the perpendicular as the base line and swing an arc whose radius $B'C$ is the cosine of the desired angle.

—G. R. GRENZKE
Wolverine Tool Company

"Automobiles of 1941" Brickbats and Bouquets

To the Editor:

Your October issue is mighty interesting reading for automobile engineers. We found several drawings in it which were not published elsewhere and altogether we think it is quite a contribution to our knowledge of the new cars.

We would like to call your attention to two errors we noticed. On page 471 it is stated that pressure cooling was first introduced on Buick in 1940. We do not know who introduced pressure cooling but we do know it has been used on Pontiac eight cylinder cars since 1937. We also noted the item about the front floor of the Pontiac, page 483, which is incorrectly written as "trunk" floor.

We think you and your associates are to be congratulated on the automobile issue.

—F. H. K.
Detroit, Mich.

To the Editor:

I enjoyed your October issue of P. E. and think you have done a particularly nice job of automobile design feature presentation. However, I was somewhat surprised that the Chrysler Simplimatic transmission incorporating a fluid coupling was described as an automatic drive. I am sure you will agree that this drive is not fully automatic except in a very narrow range of operation. The only fully automatic drive to my knowledge, is the Oldsmobile Hydromatic which you described last year. Comparative studies of the design details will show this. Also Oldsmobile is the only car that completely dispenses with the clutch pedal and its attendant mechanism.

—PARKER WILSON
Chicago, Ill.

[*Editor's Note*—Guilty again. Mr. Wilson is correct in calling our attention to a bad case of mis-labeling. With the emphasis on simplification of car operation, the word "automatic" is being used loosely for "semi-automatic."]

Case Histories in Patent Law

H. A. TOULMIN, JR.

(EDITOR'S NOTE: *The purpose of these Case Histories is to give a better understanding of the patent law in the public interest. The author advises that actual cases should be submitted to your own patent attorney.*)

No. 19

QUESTION: What happens to a patent application when the Patent Office rejects it finally?

ANSWER: The Patent Office finally rejects a patent application by the Examiner in charge of the application. Under a recent new law, the inventor, when his claims have been twice rejected, may bring the matter to a conclusion by appealing to the Board of Appeals. In the event that the Board of Appeals decides against him, then his remedy lies in either filing an appeal in the United States Court of Customs and Patent Appeals, or he may file an action against the Commissioner of Patents under Section 4915 of the Revised Statutes in the United States District Court for the District of Columbia, to compel the Commissioner to grant him a patent. In that Court he may introduce witnesses and physical and documentary exhibits to show the difference between his invention and the prior art. After his trial in this court, if the United States Judge decides against him, then he has the right of appeal to the United States Circuit Court of Appeals for the District of Columbia where the Judges of that court will review the record and the decision of the District Court below.

In Pitman et al v. Coe, Commissioner of Patents, 68 F.(2d) 412, the Court of Appeals for the District of Columbia stated:

"It has long been provided by statute that every applicant for a patent whose application has been finally rejected in the Patent Office may have either one of two alternative remedies: First, he may appeal under Section 4911, Rev. St., as amended March 2, 1929 (35 U.S.C.A. Sec 59a) to the United States Court of Customs and Patent Appeals . . ., or, second, he may file the bill in equity permitted by Section 4915, Rev. St. . . . He cannot prosecute both remedies. These two remedies lie to different courts. They differ in procedure, the one is an appeal upon the record of the Patent Office, and the other is an original suit in a court of equity. The latter proceeding calls for a trial de novo with all the customary power of an equity court to hear the evidence fully and to make its own findings."

In General Talking Pictures Corporation et al v. American Tri-Ergon Corporation et al., 96 F. (2d) 800, the Third C.C.A. stated:

". . . A suit under section 4915 is 'an original independent action in which the questions in issue are tried de novo upon all competent evidence new and old.'"

In Bakelite Corporation v. National Aniline & Chemical Company, 83 F (2d) 176, the Second C.C.A. stated:

"It cannot be doubted that the statute, as it now reads, means to give alternative remedies to an applicant to whom a patent has been refused. He may appeal, 'in which case he waives his right to proceed under section 63 of this title' (35 U.S.C.A. Sec. 59a); or he may have his remedy by bill in equity, 'unless appeal has been taken from the decision of the board of appeals to the United States Court of Customs and Patent Appeals, and such appeal is pending or has been decided, in which case no action may be brought under this section.'"

New Materials and Parts

Small Circuit Breaker

Designed primarily for protection of lighting, appliance, and motor circuits in homes, buildings and factories, this new "Quicklag" circuit breaker combines for the first time in a single unit a cooperative magnetic and thermal trip. This combination of bi-metal thermal and magnetic trip actions gives instantaneous trip on short circuits combined with time-delay for momentary overloads such as those caused by lamp, appliance, or motor inrush currents. Thermal action takes care of inrush currents for all common combinations of household appliances without unnecessary service outage. Magnetic action gives instantaneous circuit opening for all short circuits, even those in the lower

current ranges down to 200 amp. No live parts are exposed. Calibration is permanent and sealed. De-Ion grid assembly quickly snuffs out arcs. Solderless terminals are used. Automatic operation is indicated by the handle position, which has a central tripped position Case is of molded Micarta. Handle is heavy duty Moldarta and moves in grooves that prevent tampering. Available in ratings of 15 to 35 amp., single pole only, 250 volts a.c. and 125 volts d.c. Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

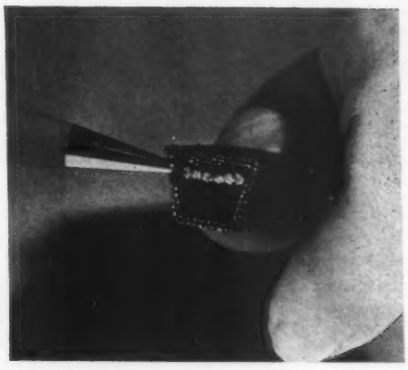
Sound-Level Meter

Portable sound-level meter, weighing only 19 lb., has a range of 24 to 120 decibels. The new meter can be used quickly and conveniently for almost any kind of a noise study including airplane engine, cabin and propeller noises; noises of motors, fans, generators, turbines, pumps and similar equipment. Essential parts of the device are a microphone, an amplifier and an indicating instrument. An arm extension protects the microphone from sound reflected from the case. Battery-operated tubes

are mounted on a shock-proof base reducing errors caused by vibration. A switch permits the selection of one of three ear-weighting networks, 40 decibels, 70 decibels or flat frequency response giving the instrument a response similar to that of the human ear. A vibration velocity unit can be substituted for the microphone as a means of measuring vibration as well as noise. General Electric Co., Schenectady, N. Y.

V-Belt Prevents Accumulation of Static

This new V-belt retains its static-discharging qualities during its entire service life. In many V-belt applications static electrical charges accumulate on the belt and discharge abruptly with a spark. In the case of domestic appliances, such as washing machines, this discharge is often more alarming than dangerous and results in complaints. In many industrial applications such as gasoline pumps and machines in chemical plants where the air might be laden with dust or inflammable vapors, this discharge might often become a serious fire hazard. One of the important features of the new static-discharging V-belt is the fact that just enough resistance is built into the belt so that the belt itself cannot act as a direct passage for current. B. F. Goodrich Co., Akron, Ohio.



Miniature Motor

Recently developed shaded pole induction motor, known as Model K, is compact, inexpensive, thoroughly dependable and meets application requirements calling for more power than pre-

vious similar motors. This new motor will deliver about four times the power output of the Model MS on a comparable temperature rise basis. Maximum continuous duty horsepower rating of 1/100 hp. is obtained. Two-pole design is employed to provide approximately

3,450 r.p.m. no-load rotor speeds. Starting torques range upward to 2¼ in. oz. Maximum running torques are 1⅓ higher than starting torques. Alliance Mfg. Co., Alliance, Ohio.

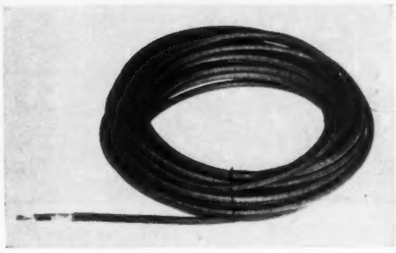
Motor With Electromagnetic Clutch

This new motor drive system for general application has an inbuilt electromagnetic clutch coupled directly to the reduction gearing which permits the driven shaft to be abruptly stopped or started in response to an electrical current or control. When the clutch disengages, a brake shoe incorporated in the clutch engages by spring action, instantly stopping the driven shaft. The drive and driven clutch members are of segmented magnetic materials. The two plates are forced together by magnetic attraction and the load is then carried by friction between the two soft iron

segmented plates. The clutch winding is mounted in a magnetic core attached to the stationary clutch housing. This core surrounds the magnetic hub of the driven member so that radial displacements do not decrease the effectiveness of the magnetic action. The clutch winding is connected in direct series with the electric motor, such that the clutching force increases as the load increases. Lear Avia, Inc., Dayton, Ohio.

Aircraft Wire

New light-weight small-diameter Deltabeston aircraft wire, which can be used to carry electrical current to any part of a plane with the greatest possible safety, is flameproof, highly resistant to heat and resistant to oil and moisture. The soft, flexible tinned copper conductor used for this wire is covered by a separator of cellulose acetate or cotton wrap, depending on the size of the conductor. The conductor is insulated with a synthetic compound and a layer of felted asbestos. The asbestos is impregnated making it highly resistant to moisture and flame. An overall impregnated flameproof braid completes the insulation. Can be used for storage



battery leads, circuit wiring for lamps, wiring for instruments, and similar purposes. Available in sizes from 22 to 2/0 inclusive. General Electric Co., Appliance and Merchandise Department, Bridgeport, Conn.

Coolant Pump

New Coolflo coolant pump has an open type, hydraulically balanced hard bronze impeller which will circulate coolant containing dirt or abrasives with minimum wear and without clogging. Standard motor is totally inclosed to prevent short-circuiting by splashing liquids, and has permanent grease-sealed ball bearings. Shaft is heavy stainless steel, requiring no coupling or

pump bearings. Casing and suction head are of high grade cast iron. Impeller is designed such that flow of coolant can be decreased as much as required without the pressure appreciably increasing, thus preventing spurting and wasteful splashing. Available for both submerged and outside mounting. Warren Steam Pump Co., Inc., Warren, Mass.

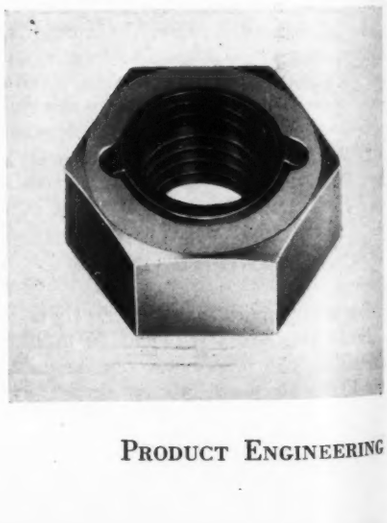
Vibrometer

Model 11 Vibrometer is an instrument for production and laboratory vibration checking. It reads actual vibration from 0.00001 to 1 in. on an open-face 9-in.

meter which is directly calibrated. A single control makes it simple to operate for indicating vibration on any machine, bearing, motor, or similar part. Sturdy auto-body steel case with engraved aluminum panel is finished in tool-gray wrinkle. Televiso Products, Inc., 200 N. Sheffield Blvd., Chicago, Ill.

Locking Nut

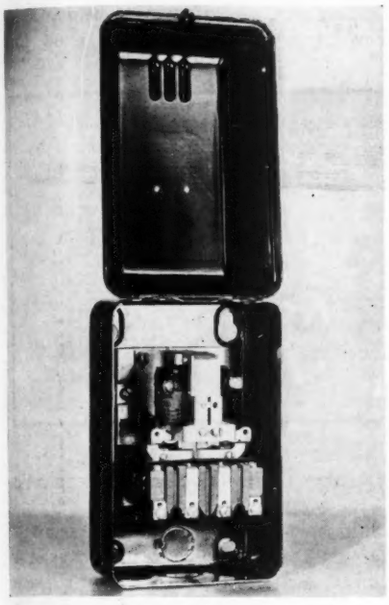
The bolt gripping element of this new Security nut consists of a slightly elliptical-shaped spring-steel retainer permanently seated in the head of a standard nut. When the nut is applied, the retainer is distorted from an elliptical into a circular shape, setting up a powerful spring pressure between the bolt threads and the retainer threads. Neither the threads of the bolt nor of the retainer are injured when applying or removing. The nut is started on the bolt with the fingers, similar to a common nut, and a wrench is used when the threads of the retainer start to engage



the threads on the bolt. Will retain its grip on the bolt after many years of application. Security Metal Products, Inc., 357 E. Kalamazoo Ave., Kalamazoo, Mich.

Inclosed Contactor

New inclosed type DN Multi-Pole Contactor, size 00, is available in ratings up to 10 amp., 600 volts a.c., and may contain as many as eight poles in any combination of normally open and normally closed contacts required for the



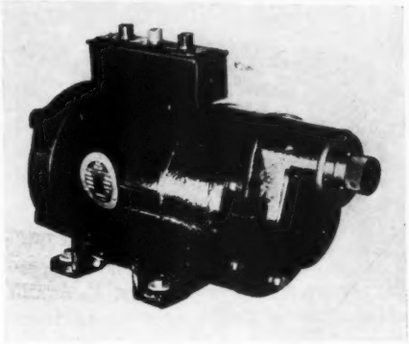
most complicated control system. The inclosure is made of black enamel sheet steel and has a deep drawn snap cover. Safety, yet ease of accessibility to the contacts themselves is thus obtained. Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.

Non-Magnetic Weldable Steel

This austenetic, tough, non-magnetic, abrasion-resisting steel can be welded without a subsequent quenching treatment or loss in toughness. Manganal contains 11–13½ per cent manganese and 3½ per cent nickel. It is claimed to correspond to an 11–14 per cent manganese steel in resistance to wear and surface work hardening. Thicknesses up to ½ in. can be sheared. It can be flame cut and requires no subsequent heat treatment when formed or punched hot. Welding rod of 18–8 stainless composition gives satisfactory results. Joseph T. Ryerson & Son, Inc., 16th & Rockwell Sts., Chicago, Ill.

Two-Speed Geared Motor

Shockproof geared motors are now available with a double winding which, together with an interlocking switch, provides the operator with a choice of two speeds changeable instantly. This new motor, the two speeds of which are controlled by a push-button switch, is of special interest to designing engi-



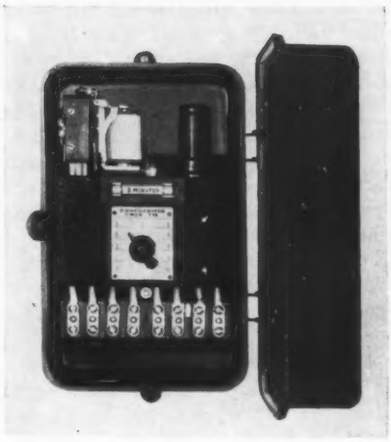
neers and manufacturers of equipment requiring instantaneous speed change, such as polishing and buffing equipment. Available in various speeds from 700 to 8,000 r.p.m. and in sizes from ¼ to 3 hp. For polyphase circuits only. Walker-Turner Co., Inc., South Ave. at Berchman St., Plainfield, N. J.

Resistors

Main feature of the new Koolohm Resistors, previously described in Product Engineering for August, page 381, is that the wire used is insulated before winding, with a hard, heat-proof and moisture proof insulation. This feature permits interleaved windings wherein adjacent wires touch, but cannot short. These interleaved windings permit high resistances to be wound in small size, using larger resistance wires. Wires 2¼ times larger in cross sectional area than customary practice are used. Windings having negligible inductance and low distributed capacitance at high radio frequencies are made practical with this insulated wire. The resistors are available in six standard types, and special units and construction can also be obtained. Sprague Products Co., North Adams, Mass.

Short Interval Timer

Universal interval timer, controlled through a specially designed snap action relay of 1,000-watt capacity, is extremely accurate over ranges from 1/20th to 2 min. The equipment is flexible with



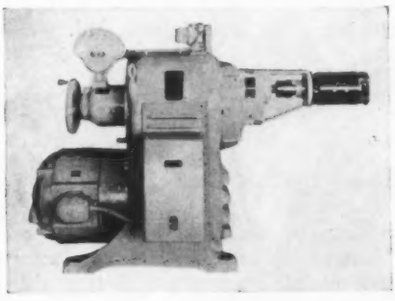
reference to actuating control, permitting both momentary pushbutton and sustaining contact control. It is universal for six timing ranges represented by timing valves snapped into a readily accessible clip. Type T15 timer has been designed with an accuracy permitting complete interchangeability of equipment. Photoswitch Incorporated, 21 Chestnut St., Cambridge, Mass.

High Speed Grain Finish

Finishing schedule that greatly reduces the time required for grain finishing uses a special speed primer as the base coat. This coat will dry out of dust in 5 min. and is ready to receive the graining ink within an hour. After the ink is dry, good results can be obtained by using a clear air-drying lacquer as the top coat and eliminating baking. When clear Codur baking lacquer is used for the top coat, the finish can be baked thoroughly in 30 min. at 275 deg. F. Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J.

Aero Test Stand

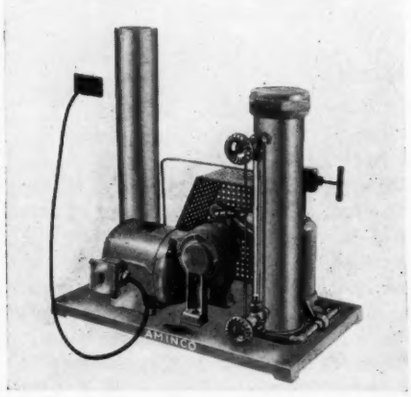
Developed for testing aircraft generators, vacuum pumps, hydraulic pumps, alternators and similar equipment, this new test stand provides positive speed changes capable of covering the full range of testing speeds. A positively



driven magneto generator and calibrated speed indicator accurately show the output r.p.m. of the test stand. The accessory to be tested is rigidly aligned by locking it in place on mounting brackets. This testing unit was developed to determine whether the generator will carry its rated load through normal operating speed and to determine whether the clutch will remain engaged throughout the normal engine operating speed. Generators can also be tested at speeds in excess of maximum operating speeds to make sure that bearings will not overheat and that the commutator and winding are strongly built. U. S. Electrical Motors, Inc., 200 E. Slauson Ave., Los Angeles, Calif.

Hydraulic Booster Pump

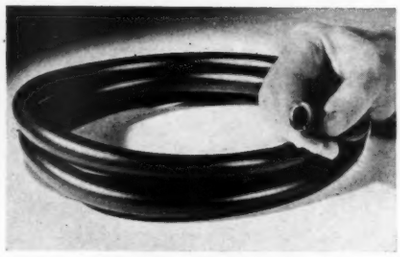
Motor-driven hydraulic pump is capable of developing pressures up to 6,000 lb. per sq.in. It is especially applicable for use in creating high test



pressures for determining bursting strengths of cylinders and spheres, for operating high-pressure and hydraulic intensifiers, and for determining the effects of high pressures and their sudden release on various materials. The pump consists essentially of a geared-head motor, reservoir and compression chamber, mounted on a substantial cast-iron base. Theoretical displacement is 553 cu.in. per hr. The pump is tested to 9,000 lb. per sq.in. pressure. Complete details are given in manufacturer's Bulletin AG–406–12A. American Instrument Co., Silver Spring, Md.

Synthetic Tubing

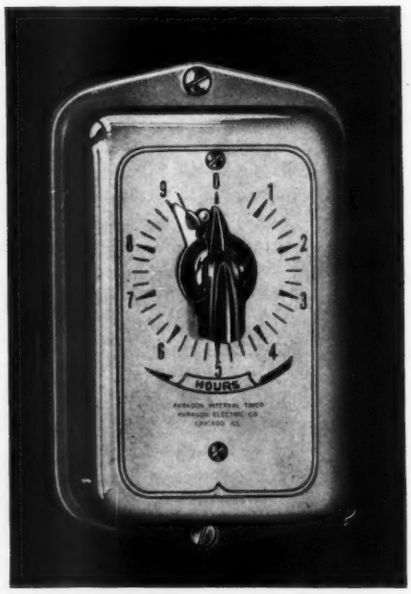
For specialized rigorous service where rubber has not been found suitable, this new special line of tubing is made of Koroseal. The hose is made without fabric or any other wall reinforcement, and withstands vacuum better than equivalent wall thickness of rubber hose. Free from sulphur, it can be attached to brass, silver, and other similar metals without corrosion. It does not swell in oil, is not affected by strong corrosives, is practically impermeable to gas diffusion and does not absorb moisture. The hose has a durometer hardness of 70-78 at 85 deg. F.; specific gravity of 1/31; working pressure of 50



lb. per sq. in. up to 120 deg. F. Available in stock diameters ranging from $\frac{1}{8}$ in. to $\frac{1}{2}$ in. with wall thicknesses from $\frac{1}{16}$ to $\frac{1}{8}$ in. Can also be made in all sizes up to 3 in. outside diameter. B. F. Goodrich Co., Akron, Ohio.

Automatic Timers

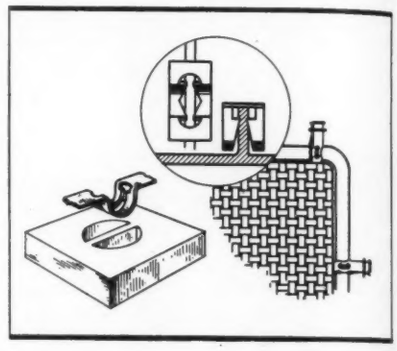
Powered by slow speed, self-starting synchronous motors and equipped with fast-acting silver contact micro-switches, these all-electric controls are designed for many types of electrical equipment



which must be accurately timed in split seconds, seconds, minutes or hours. This new series of 128 models of interval timers and time delay relays have manual or automatic reset and are available for built-in flush panel mounting, inclosed surface mounting or wall mounting. Paragon Electric Co., 37 W. Van Buren St., Chicago, Ill.

Speed Clip

An entirely new method for fastening plastics is a speed clip made of high carbon spring steel so formed that when it is pressed over a rib in the plastic material, the four sharp points of the clip bite into the side of the rib to hold the part securely in place. The clip is provided with a long retaining arm which presses firmly against the mating part under spring tension. This new method is particularly good for



fastening thin sections of thermoplastic parts where standard type speed nuts could not be used because the stud necessary on the plastic part caused a dimple or shrinkage on the surface opposite. This new principle can be applied to speed clips specially designed to meet many specific plastic assembly problems. Tinnerman Products, Inc., 2036 Fulton Rd., Cleveland, Ohio.

Plastic Resin Adhesive

Plastic resin adhesive, claimed to be the first "one-part" adhesive available for consumer and industrial users, is a urea formaldehyde glue working by chemical action, and is first cousin to Plaskon plastics. In the form of a fine powder, Meldwood glue is simply mixed with cold water, in which it dissolves instantly. No separate hardener or catalyst is used, nor is heat necessary after application. Hardens in four hours. Tests on gluing mahogany to pine, calling for a 250-lb. standard reading on the testing machine showed a strength as high as 2,400 lb., at which point the wood gave way. The bond is permanent and is waterproof because of the insolubility of the urea formaldehyde bond after polymerization. The glue is not susceptible to fungus and is stain free. Plaskon Co., Inc., Toledo, Ohio.

Manufacturers' Publications

Materials

BRONZE ALLOYS — Phosphor Bronze Smelting Co., 2200 Washington Ave., Philadelphia, Pa. Technical Data Bulletin, 12 pages, 8½ x 11 in. Describes and lists properties of Elephant Brand phosphor bronze rods, sheet and strips, welding wire, wire rope and bushings.

CASTINGS—The Electro-Alloys Co., Elyria, Ohio. Bulletin, 16 pages, 7 x 10 in. Thermalloy X-Ray Inspected Castings are set forth in this bulletin, which gives physical properties, lists grades and suggests many applications.

NEOPRENE — Rubber Chemicals Div., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. Bulletin A-7594, 26 pages, 6 x 9 in. This well-illustrated and easy-to-read booklet gives the comprehensive story of neoprene synthetic rubber.

PLASTICS—Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y. "It's a New Business Custom," 24 pages, 8½ x 11 in. This booklet presents eight success stories where Durez plastics have solved planning, sales and production problems.

PLASTIC MOLDING — Plastics Division. Erie Resistor Corp., Erie, Pa. Bulletin, 12 pages, 8½ x 11 in. Describes, with illustrations, the type of work being done by Erie in custom injection molded plastics, and includes a table of properties of molding materials.

PRE-FINISHED METALS—American Nickeloid Co., Peru, Ill. Test & Comparison Kit, containing a complete discussion of the properties of and methods for fabricating pre-finished metals, contains forms for compiling test data.

Mechanical Parts

CLUTCHES—The Carlyle Johnson Machine Co., Manchester, Conn. Catalog, 10 pages, 6¼ x 9¼ in. Contains revised data covering the Johnson Standard and Super-Johnson expanding ring friction clutches. Dimension data and engineering drawings are included.

GASKETS—Goetze Gasket & Packing Co., New Brunswick, N. J. Catalog 53, 64 pages, 8½ x 11 in. Contains advanced engineering and research data, shows many new and improved products, and gives complete size and price information. Good reference for industrial gaskets.

PUMPS—American Manganese Steel Div., Chicago Heights, Ill. Bulletin 940, 24 pages, 8½ x 11 in. Covering Amsco-Nagle Industrial pumps, complete data is given, together with characteristic curves and construction and installation views.

ROLLER BEARINGS—SKF Industries, Inc., Philadelphia, Pa. "SKF Spherical Roller Bearings," 36 pages, 8½ x 11 in. Many illustrations of roller bearing applications are given, and information on bearing selection, time-saving computations and drawings are included.

ROLLER BUSHINGS—Orange Roller Bearing Co., Inc., Orange, N. J. Engineering Data Bulletin, 20 pages, 8½ x 11 in. Complete specifications, engineering data and diagrams are given covering Orange roller bushings with and without inner races.

ROLLER CHAIN—Morse Chain Co., Ithaca, N. Y. Bulletin R-40, 92 pages, 8½ x 11 in. Information on channel-lubricated, interchangeable roller chain and sprockets, details of application, selection data and performance data are given.

SCREWS—Standard Pressed Steel Co., Jenkinstown, Pa. Form 558, 16 pages, 8½ x 11 in. Lists, illustrates and describes complete line of Unbrako Screws and keys, and Unshako self-locking nuts.

SPEED NUTS—Tinnerman Products, Inc., 2074 Fulton Road, Cleveland, Ohio. Form 135, 16 pages, 8½ x 11 in. Illustrates and explains 61 different spring-tension speed nut applications used in automobiles, radios, refrigerators, and similar products.

TANK FLANGES—United Engineering Co., 5330 Pershing Ave., St. Louis, Mo. Catalog, 10 pages, 3½ x 8½ in. Illustrates and gives specifications for complete line of welding tank flanges, adapters and forgings.

V-BELTS—B. F. Goodrich Co., Akron, Ohio. "V-Belt Data Book," 170 pages, 4 x 7 in. Gives alphabetical listings of belt requirements for all types of equipment, listing the manufacturer's part number and the Goodrich belt number and size. Numerical group listings for both V- and flat belts are also given.

V-BELT DRIVES—Pyott Foundry & Machine Co., 328 N. Sangamon St., Chicago, Ill. Catalog V-500, 112 pages, 8½ x 11 in. Features "Economy Tables," for quick selection of correct drive arrangement, and includes revised V-belt ratings and many typical applications.

Electrical Parts

CIRCUIT BREAKERS—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Bulletin 29-060, 12 pages, 8½ x 11 in. Lists and describes De-Ion breakers for load center, panelboard, switchboard or inclosure mounting.

CONTACTS—Gibson Electric Co., 8358 Frankstown Ave., Pittsburgh, Pa. Catalog C-10, 15 pages, 8½ x 11 in. Fully describes eight standard Gibsiloy contact alloys in the form of ductile powdered metals. Much technical data is given, including graphs and drawings showing mechanical applications.

ELECTRICAL PRODUCTS — Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. "Quick Selector" Catalog 30-000, 64 pages, 8½ x 11 in. Revised edition of handy catalog which simplifies selection of electrical equipment for any motor, lighting or feeder circuit.

MOTOR CONTROLS — Trumbull Electric Mfg. Co., Plainville, Conn. "Trumbullist," 52 pages, 8½ x 10 in. Describes complete line of Trumbull motor controls and includes the new Multi-Breaker Power Panel and Motor Control Centers.

PHOTOELECTRIC RELAYS—General Electric Co., Schenectady, N. Y. Bulletin GEA 1755C, 4 pages, 8 x 10½ in. Sets forth features and application data on photoelectric relays and accessories.

RELAYS—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Bulletin 41-350, 4 pages, 8½ x 11 in. Gives descriptive, construction and electrical and mechanical data on the Type SG Auxiliary Control Relay.

RESISTORS AND RHEOSTATS—Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill. Catalog 40, 96 pages, 8½x11 in. An encyclopedia of data on the selection of resistors, rheostats, tap switches, chokes, and attenuators, this catalog contains handy reference tables, dimension drawings and special guide pages.

TIME SWITCHES—General Electric Co., Schenectady, N. Y. Bulletin GEA-2963B, 4 pages, 8 x 10½ in. Illustrates and describes Type TSA-14 time switches for control of a.c. circuits.

VARNISHED TUBING—William Brand & Co., 276 Fourth Ave., New York, N. Y. "The Unvarnished Truth About Flexible Varnished Tubing," 4 pages, 8½ x 11 in. Sets forth features of Turbo varnished tubing and saturated sleeving.

Finishes

PAINTING — Industrial Paint Clinic, American-Marietta Co., 43 East Ohio St., Chicago, Ill. Maintenance Painting Handbook, 120 pages, 5 x 7 in. All-inclusive information on maintenance painting, giving correct applications of complete Valdura line of paints.

WEATHERING UNIT—National Carbon Co., Inc., Carbon Sales Div., Cleveland, Ohio. Catalog Sec. L-6400, 8 pages, 8½ x 11 in. A complete unit for accelerated weathering tests of protective and decorative coatings, plastics, rubber, etc., is illustrated and described.

Books and Bulletins

Aerosphere 1939

EDITED BY GLENN S. ANGLE—*1,420 pages, 9¼x12 in. Blue clothboard covers. Published by Aircraft Publications, 370 Lexington Ave., New York, N. Y. Price $15.*

This new publication is a complete reference encyclopedia of the aircraft industry—an American counterpart to Jane's All the World Aircraft. Aerosphere 1939 is the first volume of a series which will be re-edited and brought up-to-date at the end of each year. Data given are astonishingly complete, particularly for aircraft engines, and the book will undoubtedly fill a great need to all those persons connected directly or indirectly with aircraft.

Subject matter is divided into four sections. In the first section are given illustrated technical descriptions of nearly every aircraft engine developed in any country since Clement Ader built a 2-cylinder steam engine in France and flew 150 ft. with it in 1890. This section is neatly cross-indexed and principal specifications are tabulated.

The second section catalogues and illustrates all modern aircraft, grouped by country and manufacturer. Specifications and performance data are as complete as possible.

The third section gives all important aircraft statistics, such as records, lists of members of aircraft committees, agencies, and associations, tabulated air mail data, pilot statistics, listings of aeronautical schools, and many other world-wide aeronautic facts and figures.

The fourth section is an Aircraft Directory, giving complete listings of companies and personnel engaged in aircraft activities covering aircraft, engine, and accessories, arranged both alphabetically and by product. Much more data too numerous to mention are also included in this section.

Silver in Industry

LAWRENCE ADDICKS—*636 pages, 6x9 in. Red clothboard covers. Published by Reinhold Publishing Corp., 330 West 42nd St., New York, N. Y. Price $10.*

Sponsored by a group of American silver producers this book has been written to help silver find its rightful place in the family of useful metals. Various chapters have been contributed by men well qualified to deal with them.

Included in the twenty chapters are those which cover the properties of silver, binary alloys, ternary and engineering alloys, technology of silver, low temperature and high-temperature bonding of silver, use of silver in bearings, coatings, silver in electrical contacts, and corrosion resistance of silver and silver alloys. Appendixes list a long bibliography and patent index.

This volume brings together much information of practical and also speculative value to industries who are using or contemplating the use of silver as an industrial metal, as well as those who are interested in markets for this precious metal.

A Dictionary of Metals And Their Alloys

EDITED BY F. J. CAMM—*245 pages, 5½x8½ in. Blue clothboard covers. Published by Chemical Publishing Co., 148 N. Lafayette St., New York City. $3.*

All metals and almost every type of commercial metallic alloy is included in this dictionary, designed for use by the busy reader who needs a mass of ready information. A description of the metals, their composition and characteristics is contained in the book with special sections on plating, polishing, hardening and tempering, metal spraying, rust proofing, chemical coloring and 17 pages of useful tables.

Engineering Mechanics

S. TIMOSHENKO AND D. H. YOUNG—*Second Edition. 523 pages, 6x9 in. Green clothboard covers. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York, N. Y. Price $4.*

This volume is not only a text book dealing with the theories and principles of mechanics, it is also an example book designed particularly to provide the engineering student with the many general methods for later attacking problems which require for their solution a broad knowledge and a sound foundation in the principles of mechanics.

First published in two volumes this second edition of one volume has been made possible by reducing the quantity of text through rewriting with a shorter and more direct approach, some rearranging of material, and omitting some of the more advanced problems.

The book naturally divides into two major parts. Part I discusses the principles of statics; concurrent, parallel and general cases of forces in a plane; forces and couples in space; and the principle of virtual displacements. Part II covers principles of dynamics, rectilinear and curvilinear translation; rotation of rigid bodies; plane and relative motion. The text is well supplemented with problems.

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Standard Specifications for Steel

Data Sheet Section 7, No. 1, 20 pages, 6¾x8¾ in. Published by International Nickel Co. Inc., 67 Wall St., New York, N. Y.

This revised data sheet incorporates the latest additions and revisions in the S.A.E. Standard Specifications for Steels, and in the A.S.T.M. Standard Specifications for Alloy Steel Castings for structural purposes. These widely used specifications have been supplemented by sketches showing test specimens now currently in use for steel in tension, compression, bending, notched bar impact, torsion and fatigue testing.

Aluminum Pistons

46 pages, 5¼x8¼ in. Published by Aluminum Co. of America, Pittsburgh, Pa.

Prepared by the Dynamic Laboratory of the Aluminum Company of America, this booklet is an excellent general treatise on aluminum pistons and aluminum cylinder heads. The first chapter illustrates and describes the various types of pistons, discusses their chief advantages, and lists their applications. Chapter II explains the properties and characteristics of various types of piston material. Finishes necessary for aluminum pistons and cylinders are covered in Chapter III, and Chapter IV discusses aluminum cylinder heads.

Thermocouples

Catalog N-33-A(6), 40 pages, 8½x11 in. Published by Leeds and Northrup Co., 4934 Stenton Ave., Philadelphia, Pa.

Considerable useful general engineering information is given in this catalog on the proper selection of a couple for a given application. General recommendations for thermocouple wires and test methods are covered. Also, the bulletin devotes several pages to a discussion of tubes and wells for protecting thermocouples, including a table listing tube and well materials for specific applications.

ALUMINUM and MAGNESIUM PRODUCTS with corresponding FEDERAL, ARMY, NAVY, S.A.E. and A.S.T.M. SPECIFICATIONS

ALUMINUM and MAGNESIUM PRODUCTS with corresponding FEDERAL, ARMY, NAVY, S.A.E. and A.S.T.M. SPECIFICATIONS

ALUMINUM PRODUCTS	FEDERAL	ARMY	NAVY	S.A.E.	A.S.T.M.
Sheet and Plate					
2S	QQ-A-561	57–151–1A	47A2d	25	B25–38T, B126–39T
3S	QQ-A-359	Federal	47A4c	29	B79–38T
4S				20	
17S	QQ-A-353	Federal	47A3c	26	B78–36T
17S Alclad		57–152–2A	47A6b		
24S	QQ-A-355	Federal	47A10c	24	
24S Alclad		11067	47A8b		
27S			47A13 (INT) (4/39)		
52S	QQ-A-318	Federal	47A11b	201	B109–36T
53S	QQ-A-334	Federal	47A12a		
61S		11326			
3S Tread Plate			47A7	29	
53S Special Floor			SPS-1087		
Tubing					
2S	WW-T-783	Federal	44T19a (INT) (4/39)	25	
3S	WW-T-788a	Federal	44T20a	29	
4S		11069		20	
17S Round	WW-T-786	Federal	44T21c	26	
17S Streamlined		57–187–2B	44T22a	26	
24S Round		10235-A	44T28a	24	
24S Streamlined		57–187–2B	44T31a	24	
52S		57–187–3	44T32	201	
53S			44T30a		
3S Voice Tubing			44T5c		
Bar, Rod, Wire, and Shapes					
2S	QQ-A-411a	Federal	46A3d	25	
3S	QQ-A-356a	Federal	46A6e	29	
4S				20	
17S	QQ-A-351a	Federal	46A4f	26	B89–36T
24S	QQ-A-354	Federal	46A9c	24	
27S			46A12 (INT) (4/39)		
52S			46A11	201	
53S	QQ-A-331a	Federal	46A10a		
56S	(See RR-C-451a)		See 15C1 (INT), See 17C11c, See 42C12g		
2S Metal Spraying		10285			
72S Metal Spraying			A25		
2S Welding Rod	QQ-R-571	Federal	46R1 (INT) (2/39)	25	
43S Welding Rod	QQ-R-571	Federal	46R1 (INT) (2/39)		
Rivets and Rivet Rod and Wire					
2S		25526-A	43R5d	25	
3S			43R5d	29	
17S		25526-A	43R5d	26	
A17S		25526-A	43R5d		
24S		25526-A	43R5d		
53S			43R5d		
Bolts, Nuts, Studs, etc.					
17S	FF-B-571a	29–59-B	43B11 (INT) (9/38)	26	
17S Machine Screws	FF-S-91	Federal	42S5d	26	
24S		29–59-B	43B13a		
24S Machine Screws			43S4		
Forgings					
14S	QQ-A-367a	Federal	46A7b		
17S	QQ-A-367a	Federal	46A7b	26	
18S	QQ-A-367a	Federal	46A7b		
25S	QQ-A-367a	Federal	46A7b	27	
32S	QQ-A-367a	Federal	46A7b		
A51S	QQ-A-367a	Federal	46A7b	280	
Ingot					
99% Aluminum	QQ-A-451	Federal	46A2b		B24–39T
98% Aluminum	QQ-A-451	Federal	46A2b		B24–39T
99.5% Aluminum	QQ-A-451	Federal	46A2b		B24–39T
Specified Analysis	QQ-A-451	Federal	46A2b		
94% Metallurgical					B37–39T
43	QQ-A-371a	Federal, 11079-A	46A5c		B58–37T
47					B58–37T
108	QQ-A-371a	Federal			
109	QQ-A-371a	Federal			B58–37T
112					B58–37T
122	QQ-A-371a	Federal			B58–37T
142	QQ-A-371a	Federal			B58–37T
195	QQ-A-371a	Federal, 11079-A	46A5c		B58–37T
196					B58–37T
212	QQ-A-371a	Federal			B58–37T
214			46A5c		B58–37T
356	QQ-A-371a	Federal	46A5c		
Ingot for Permanent Mold Castings					B112–38T
Ingot for Die Castings					B125–39T
Sand Castings					
12				30	
43	QQ-A-601	Federal, 11311	46A1e	35	B26–37T
47				37	B26–37T
108	QQ-A-601	Federal, 11312			
109				32	B26–37T
112				33	B26–37T
122	QQ-A-601	Federal	M212a (8/24/34)	34	B26–37T
132			M212a (8/24/34)		
A132	QQ-A-601		M212a (8/24/34)	321	B26–37T
142	QQ-A-601	Federal, 57–72–1C	M212a (8/24/34)	39	B26–37T
195	QQ-A-601	Federal, 57–72–5B	46A1e	38	B26–37T
196					B26–37T
212	QQ-A-601	Federal, 11310		36	B26–37T
214	QQ-A-601	Federal, 57–72–4A	46A1e	320	B26–37T
220		11309-A	M-186c (1/4/39)	324	
254			M212a (8/24/34)		
355	QQ-A-601	Federal, 11307-A	M212a (8/24/34)	322	B26–37T
A355	QQ-A-601	Federal	M212a (8/24/34)		
356	QQ-A-601	Federal, 11308-A	46A1e	323	B26–37T
645				31	
Die Castings					
13	QQ-A-591	57–93–1B	46A14	305	B85–37T
13 Special Purity	QQ-A-591				
43	QQ-A-591	57–93–1B	46A14	304	B85–37T
43 Special Purity	QQ-A-591				
81	QQ-A-591		46A14	312	B85–37T
85	QQ-A-591	57–93–1B	46A14	307	B85–37T

(Continued on next page)

ALUMINUM and MAGNESIUM PRODUCTS with corresponding FEDERAL, ARMY, NAVY, S.A.E. and A.S.T.M. SPECIFICATIONS

ALUMINUM PRODUCTS	FEDERAL	ARMY	NAVY	S.A.E.	A.S.T.M.
Die Castings—Con'td					
93	QQ-A-591	57–93–1B	46A14	309	B85–37T
214 Special Purity	QQ-A-591				
218	QQ-A-591				
2Z Zinc Alloy				921	B86–34T
3Z Zinc Alloy				903	B86–34T
Permanent Mold Cast					
43	QQ-A-596		46A15	35	B108–38T
A108	QQ-A-596		46A15		B108–38T
C113	QQ-A-596		46A15		B108–38T
122	QQ-A-596		46A15	34	B108–38T
A132	QQ-A-596		46A15	321	B108–38T
138					B108–38T
142	QQ-A-596		46A15	39	B108–38T
B195	QQ-A-596		46A15		B108–38T
355	QQ-A-596		46A15	322	
356	QQ-A-596		46A15	323	B108–38T
Miscellaneous Products and Processes					
Analysis of aluminum and light aluminum alloys			General Specifications for Inspection of Material. (See SR19d)		B40–36T
Anodic Oxidation Process (Alumilite 205) (Alumilite 710)		(See 98–20005B)			
Bus Bars for switchboards			17B12		
Chairs		50313	26C6f		
Cable, Insulated Electric (56S Armor)			15C1 (INT) (3/39		
Couplings for Tube and Hose (17S-T)			M-334		
Conduit, Flexible Shielded			17C11c		
Flexible Tubing		10236-C	33T3 (INT)a (7/39)		
Floor Gratings, Ship			12G7		
Flux, Welding		11313	51F6		
Foil		11074	47A5b		
Furniture			26F4c		
Heat Treatment		98–10026-B	SR53b		
Pipe Fittings			45F13		
Pipe Threads, Taper		25525-A	M-262b (7/3/36)		
Paste, Aluminum for Paint, Standard	TT-A-466	Federal	52A1 (INT) (3/39)		D474–38T
Paste, Aluminum Pigment, Extra Fine	TT-A-166	Federal	RM-137-1(1/3/38)		D474–38T
Powder, Aluminum for Paint, Standard	TT-A-476	Federal			D266–38T
Powder, Aluminum Extra Fine Lining	TT-A-476	Federal	RM-137-1 (1/3/38)		D266–38T
Primer, Zinc Chromate			P-27b		
Propellers for Aircraft		98–29518J 29521	M-65b-1		
Safety Treads, Cast (Abrasive Surface)			12T4 (INT) (3/39		
Varnish, Mixing, for Aluminum Paint	TT-V-81		52V15c		
Varnish, Spar (Phenolic resin)			V-10e (7/12/38)		
Varnish, Spar (Glycerylphthalate)			V-11e (7/12/38)		

MAGNESIUM PRODUCTS	FEDERAL	ARMY	NAVY	S.A.E.	A.S.T.M.
Sheet					
AM3S		11317	M-111e (3/15/40)		B90–36T
AM53S					B90–36T
AMC57S			M-111e (3/15/40)		
Tubing					
AM3S		11318	M-366b (3/15/40)		
AMC57S		11318	M-366b (3/15/40)		
AM74S		11318	M-366b (3/15/40)		
Bar, Rod, Wire, Shapes					
AM3S		11320	M-314c (3/15/40)		B107–38T
AM53S					B107–38T
AM57S					B107–38T
AMC57S		11320	M-314c (3/15/40)		
AM58S					B107–38T
AM74S		11320	M-314c (3/15/40)		
Forgings					
AM3S			M-126d (3/14/40)		B91–38T
AM53S					B91–38T
AM57S					B91–38T
AMC57S			M-126d (3/15/40)		B91–38T
AM58S		11321	M-126d (3/15/40)		B91–38T
AM65S					B91–38T
AM74S			M-126d (3/15/40)		B91–38T
Ingot					
Magnesium Ingot		57–21			B92–36T
AM240 Alloy					B93–36T
AM241 Alloy					B93–36T
AM246 Alloy					B93–36T
AM265 Alloy					B93–36T
AM403 Alloy					B93–36T
Sand Castings					
AM240					B80–36T
AM241					B80–36T
AM246					B80–36T
AM260			M-112g (3/15/40)		
AM265		57–74–1C	M-112g (3/15/40)		B80–36T
AM403			M-112g (3/15/40)		
Die Castings					
AM230		11319	M-369 (3/15/39)		
AM240		11319	M-369 (3/15/39)		B94–37T
AM263		11319	M-369 (3/15/39)		
Miscellaneous Protective Treatment					
(a) AMA Chrome Pickle		98–20010-A	M-303a (4/1/39)		
(b) AMH Modified Alkali Chromate			M-382		
(c) AMK Galvanic Anodizing			M-395		
(d) AML Sealed Chromate Pickle			M-406		
(e) AMG Dichromate Treatment		98–20010-A	M-407		
(f) AMC Chrome Sulphate			M-408		
(g) Anodic Oxidation			PT-13d		
Methods of Physical Testing	QQ-M-151a	Federal	General Specifications for Inspection of Material		E8–36